A price reflects the outcome of an economic process. Often this process is unobservable to a researcher. Prices, however, are often observable. For that reason researchers try to discover patterns in price data to understand the underlying, but often hidden, economic process.

This thesis studies price data and tries to unravel the underlying economic processes of why firms have chosen these prices. It focuses on three aspects of price setting. First, it studies whether the existence of a suggested price has a coordinating effect on the prices of firms. Second, it studies whether firms adjust their prices asymmetrically to changes in costs. Third, it studies the effects of European integration policy on consumer prices.

Riemer P. Faber (1981) graduated in economics at the University of Groningen. In September 2005 he joined the Tinbergen Institute and Erasmus University Rotterdam for his Ph.D. research. Two of his papers have been published in the *Journal of Money, Credit and Banking*.

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Preface

The last four years I worked with pleasure on this thesis. I would like to thank Maarten Janssen for being my supervisor and coauthor of Chapter 2. I thank Ad Stokman as coauthor of Chapter 4. I also thank Heleen Hofmans.

Finally, I thank the members of the doctoral committee, all colleagues at the Tinbergen Institute and Erasmus University Rotterdam, and everybody who helped me collecting the data that I use in this thesis (in particular Rikkert Nachtegaal).

Contents

Chapter 1

Introduction

Price setting of firms is of importance to almost everybody. Consumers would like to know where they can find the best price/quality combination. Firms would like to know how they should choose optimal prices and how their competitors set prices.

Economists see prices as an outcome of an economic process. Often this process is unobservable to a researcher. Prices, however, are often observable. For that reason researchers study patterns in price data to understand the underlying, but often hidden, economic process.

Firms' price setting is also important for many aspects of daily economic practice. Competition authorities want to know whether firms set their prices above competitive levels and how they can prevent firms from doing this. Central banks want to know the degree to which firms change prices and how they can influence these price changes via the interest rate. Governments and international organizations want to see if their policy (tax levels, the decision to join the European Union, etc.) is effective and has an impact on economic processes and thus on the price setting of firms. Policy researchers want to understand the relation between prices and other variables in their models to improve both the descriptive and predictive properties of their models.

This thesis adds to the understanding of firms' price setting. I study both micro and macro price data and search for patterns in these data. Via these patterns I find determinants of prices and I detect the reasons why firms chose their prices. In this thesis I focus on three aspects of price setting. First, I study whether the existence of a suggested price creates a focal point and has a coordinating effect on the prices of firms. Second, I study whether firms adjust their prices asymmetrically to changes in costs. Third, I study the effects of European integration policy on consumer prices in different countries.

The remainder of this introduction first briefly discusses the three aspects of price setting that I focus on in this thesis. Then I give an outline of the thesis.

1.1 Three aspects of price setting

1.1.1 Price setting and suggested prices

To what degree should information on prices be public? In general, information is good for consumers. Transparency in a market makes it easier for consumers to compare prices and take advantage of price differences between firms. However, next to consumers, also firms observe public information on prices. Firms can use this information to coordinate pricing decisions.

In general, all firms in a market can obtain higher profits if they do not set their prices individually, but instead coordinate their pricing decisions. For example, firms can coordinate on a certain price level or on a certain price ranking. However, what is the price that all firms should charge? Or alternatively, how should all firms change their prices after, for example, a demand or cost shock? There are many possibilities that all result in higher profits than the profits in a situation without coordination, as long as all firms choose the *same* price or the *same* price change. This problem is particularly difficult when the optimal price frequently changes. One way for firms to coordinate is to use a focal point. A focal point naturally stands out as the obvious choice from the set of all possibilities (see Schelling (1960)). A maximum price set by the government may act as such a focal point. Knittel and Stango (2003) show that U.S. credit card companies used a government imposed nonbinding price ceiling as a focal point for tacit collusion during the early 1980s. In many markets, a natural focal point for coordination does not exist. In that case a party concerned can create a focal point, for example, by publicly announcing a certain price.

One type of public price announcement that may create a focal point is a “suggested price”. This price is announced with the suggestion that retailers charge this price. Retailers are completely free to deviate from this price. Moreover, there are substantial costs for a retailer to check whether its competitors really charge the suggested price, especially if the suggested price changes very often. Competition law usually allows public price announcements like suggested prices. This is in line with the view of economists who, in general, consider the positive welfare effect of public information due to better informed consumers as larger than the negative welfare effect due to possible coordination of firms’ pricing decisions (Motta (2004)). However, differences may exist between different types of price announcements and the markets where firms use these announcements.

Farrell (1987) shows that in theory costless, nonbinding, and nonverifiable communication (“cheap talk”) can help firms to choose an equilibrium out of multiple possible equilibria. Laboratory studies confirm this finding (for an overview of the experimental literature see Holt (1995) and Cason (2008)). However, there is no empirical evidence that shows that a nonbinding suggested price helps firms to coordinate (Foros and Steen (2008) study suggested prices, but in their case suggested prices are de facto a resale price maintenance arrangement).

1.1.2 Price setting and asymmetric price responses

Among consumers there is a wide perception that firms quickly raise prices after an increase in costs, but that firms do not immediately lower prices after a decrease in costs. “Prices rise like rockets, but fall like feathers.” Consumers are in particular suspicious with regard to gasoline stations. Possibly because there is only one major input for gasoline and the cost of this input is relatively transparent.

Traditionally, economists have always questioned the “Rockets and Feathers” hypothesis since from a standard theoretical perspective there is no obvious reason why firms would want to set their prices in this way. However, there is quite some empirical evidence in favor of this “asymmetric pricing”. Peltzman (2000) uses data on many different markets and finds that in more than two out of three markets prices respond faster to increases than to decreases in the input price. A natural extension is to carefully look inside one specific market to better understand to what extent and why asymmetric pricing exists in this market. For example, Borenstein, Cameron, and Gilbert (1997) study market prices of gasoline at several stages of the production and distribution chain. Of course, price data at the firm level can give even more insights because individual firms take the decision whether to respond asymmetrically to changes in costs. Individual decision makers can differ in their pricing strategies or in the way that they implement these strategies.

Understanding asymmetric pricing is important for many policy issues. For example, it is important for central banks to understand the relation between changes in costs and consumer prices. Via their knowledge of pass-through of shocks and stickiness of prices, central banks can predict changes in consumer prices and possibly anticipate on these. Moreover, it is important for policy makers to understand the reason for asymmetric pricing. The cause determines whether policy makers should interfere in markets where they observe asymmetric price adjustments. For example, if asymmetric pricing is a sign of collusion, then competition authorities may want to further investigate markets where firms set prices in this way.

1.1.3 Price setting and European integration policy

Government policy can have a strong impact on the price setting of firms. Governments decide, for example, on the minimum wage, the level of taxes, the degree of trade liberalization, or the exchange rate regime. Moreover, the prices of firms abroad are important for a firm's pricing strategy. If a product is cheaper abroad, arbitrage will occur, forcing domestic firms to lower their prices.

After the Second World War, European countries decided to integrate their national markets to increase the economic dependence of countries and make wars too costly to occur. As a result, European countries intensively cooperated to integrate their national markets in the last 50 years. Milestones in the integration process are the signing of the Treaty of Rome on the establishment of the European Economic Community (1957), the completion of the Single Market (1993), and the introduction of the euro (1999). However, European integration is not a gradual process. Periods of intense cooperation and milestones interchange with periods of stagnation (see, e.g., Gros and Thygesen (1998)).

Did European countries succeed in integrating their national markets? Understanding how successful past policy has been can help to decide how much more integration policy Europe still needs. Moreover, it helps to understand which policy measures work for integrating markets. One way to measure the effectiveness of the integration policy is to measure price differences between European countries. Markets that are more strongly integrated have smaller price differences. A first reason is that if international transactions are cheaper, buying abroad is attractive at lower price differences. So the effect of the border, that separates markets, declines (Engel and Rogers (1996)). As a consequence, for both domestic and foreign firms the price on the other side of the border becomes more important for setting their prices. Their prices will converge. Examples of European policy that lowered the costs of international transactions are the demolition of (non)tariff barriers and the removal of exchange rate volatility. A second reason is that integration policy may make cost structures more similar. Also this will lower price differences between European countries. Examples of European policy that may result in more similar cost structures across countries are the structural and cohesion funds that support the poorer regions in Europe, the increase in labor mobility, and the harmonization of tax rates. Moreover, a higher degree of free trade may also result in more similar cost structures (factor price equalization).

A market where price differences between European countries are notorious is the car market (Goldberg and Verboven (2005)). The European Commission has considered this market as a test case and has put special emphasis on its integration. Goldberg and Verboven (2005) find evidence that price differences between cars decline over time (1970-2000), suggesting that European integration policy has been successful. If this is true, then price differences in other markets should have been declining as well. However, other studies that look at a broader set of products during different parts of the 50 years of European integration find mixed results (see Allington, Kattuman, and Waldmann (2005), Crucini, Telmer, and Zachariadis (2005), and Rogers (2007)). Possibly, like European integration policy, price level convergence takes place in shocks and with periods of stagnation. For that reason the impact of integration on firms' price setting may depend upon the period under evaluation.

1.2 Outline of the thesis

This thesis studies the three aspects of price setting that I introduced in the previous section. Each of the three following chapters discusses one of these aspects.

Chapter 2 is on price setting and suggested prices. Oil companies announce suggested prices for gasoline in the Netherlands. On a daily basis, oil companies announce a price that they advise retailers to set for one liter of gasoline. I study the effects of these suggested prices. There are at least two competing rationales for the existence of these suggested prices: they may either help retailers translate changes in the international gasoline spot market price into retail prices, or they may coordinate prices. I use a data set with daily retail prices of almost all gasoline stations in the Netherlands and suggested prices of the five largest oil companies over more than two years. I show that there is, compared to the international spot market price, additional information in suggested prices that explains retail prices. Therefore, I conclude that suggested prices help to coordinate prices. I consider different interpretations of this empirical finding. I also discuss the role of multiple suggested prices as the five largest oil companies each set their own suggested price. To my best knowledge, this chapter is the first study that empirically tests the coordinating effect of suggested prices.

Chapter 3 studies price setting and asymmetric price responses. Using the same data set as in Chapter 2, I study the daily pricing behavior of almost all oil companies and gasoline stations in the Netherlands. I find that none of the five largest oil companies adjust their suggested prices asymmetrically. I also find that there exist important differences between gasoline stations. Many stations do not adjust their retail prices asymmetrically. However, a substantial part of the stations do. I measure the extent of asymmetry at the station level. I also study characteristics of stations that do and do not adjust prices asymmetrically. Previous research mainly focuses on asymmetry in markets as a whole. Chapter 3 is the first study that looks at differences in the asymmetric pricing behavior of individual firms.

Chapter 4 discusses price setting and European integration policy. More specifically, I study long-term price level convergence in Europe. I detect trends in price level dispersion starting from the earlier days of economic cooperation in Europe and identify the main determinants behind this process. To create long-term price level data that are comparable across countries, I combine time-series information on harmonized indices of consumer prices with occasional observations of absolute price levels. I find that European price levels converged over much of the last five decades. I compare the development of price level dispersion in Europe to the development in the United States. Moreover, I study the impact of indirect tax rate harmonization, convergence of nontraded input costs, and convergence of traded input costs (in the form of exchange rate stability and increased openness). This chapter is the first study that provides documentation of the evolution of price level dispersion in Europe and its determinants over a long period.

Chapter 5 concludes. It provides a summary of the main findings and some directions for further research.

Chapter 2

Price Setting and Suggested Prices: On the Effects of Suggested Prices in Gasoline Markets*

Joint work with Maarten C.W. Janssen

Both from an academic and from a more practical point of view, there is considerable interest in what constitutes price setting under normal conditions of competition and where the boundary with price collusion lies. This issue is particularly prominent in connection with the issue of how to interpret the existence of suggested prices. There is a wide suspicion that suggested prices distort the normal functioning of markets (see, e.g., Kühn (2001) and Motta (2004)). Suggested prices may act as an attraction or focal point for firms coordinating their pricing decisions as the suggested price stands out among all possible prices they could coordinate on. The role of suggested prices is potentially important, but not well understood. This chapter performs an empirical analysis testing the coordinating effect hypothesis of suggested prices in the Dutch gasoline market. To our knowledge, the coordinating effect hypothesis has to this point only been based on anecdotal evidence and tested in an experimental setting (see, for example, Holt (1995) and Cason (2008)).

We define suggested prices as prices that are announced with the suggestion that retailers follow them. Suggested prices can be chosen by professional organizations (e.g., the organization of notaries, or of psychologists) or by large producers higher up in the product chain (such as oil companies). Suggested prices can be communicated openly via websites or can be more hidden, via letters or e-mails sent only to retailers. Depending on the sector,

* An earlier version of this chapter is "On the Effects of Suggested Prices in Gasoline Markets", Tinbergen Institute Discussion Paper, November 2008, 116/1.

suggested prices can be changed either infrequently or on a daily basis. Suggested prices are not binding in any legal way and retailers are free to deviate and charge higher or lower retail prices as they wish. As such, they should not be considered as minimum or maximum prices.

There are quite a few cases where different competition authorities have argued that by setting suggested prices, companies or professional organizations have violated competition law. Recently, one such a case was where the Dutch competition authority (NMa) decided that several Dutch organizations for psychology and psychiatry were guilty of violating competition law as they advised their members via their website how much to charge per hour given the costs members typically would encounter.[1] What, according to the organization, was meant as an aid to their members, was judged by the Dutch competition authority as a way to coordinate pricing decisions of individual entrepreneurs above competitive levels. The Dutch competition authority argued that suggested prices helped to considerably reduce the uncertainty concerning competitors' price setting behavior. Uncertainty concerning competitors' main strategic decisions was considered to be crucial to the competitive process. The decision of the Dutch competition authorities was based, among other things, on some EU decisions (e.g., concerning suggested prices in the crane renting sector) taken already as early as 1995.[2]

A similar ruling was made in a private U.S. case on petroleum products.[3] The complaint was that oil companies conspired to raise or stabilize prices by disseminating information concerning wholesale and retail prices, with the purpose of quickly informing competitors in the hope they would follow suit. The court's analysis was to a large extent based on the

[1] See NMa decision case 3309/NIP, LVE, NVP, and NVVP 2004. The decision has been successfully challenged by the professional organizations involved. In a decision on 6 October 2008 the court of appeal (CBb) cancelled the decision on the basis that it was not clear that the price was a decisive factor in the decision process of consumers while choosing a psychologist (LJN: BF8820, CBb, AWB 06/667).

[2] See, e.g., XXVth Report on Competition Policy 1995, European Commission, p. 118.

[3] See, e.g., In re Coordinated Pretrial Proceedings in Petroleum Products Antitrust Legislation 906 F.2d 432 1990 and Hay (1999). Borenstein (2004) studies another related case.

judgment that they did not see any other business purpose than to facilitate interdependent or collusive interaction.

As far as gasoline markets are concerned, suggested prices are quite common in many European countries, such as the Netherlands, Germany,[4] and Italy[5] (see also OECD (2001)). Typically, larger oil companies announce on their websites on a daily basis the prices they advise retailers to set for their gasoline.[6] As the international gasoline prices change rapidly (from day to day), suggested prices also fluctuate frequently. Retailers are free to deviate from these prices. Apparently, as the existence of these suggested prices is not a secret, competition authorities think they do not obstruct the competitive process in this particular market.

What can be the economic rationale for setting suggested prices in the gasoline retail market and what can be the rationale for allowing this practice in this sector, in spite of the fact that similar practices are not allowed in other sectors? We can think of two reasons why oil companies publish suggested prices: (i) to help small retailers by informing them how they could take the frequent changes in the gasoline spot market price into account when setting retail prices, and (ii) to coordinate pricing decisions. We do not see other convincing business purposes.[7] Some oil companies explicitly claim to have suggested prices for the first reason (see, e.g., the Shell website and Shell (2001)).

It is important to realize that the first reason can also cause price coordination, namely with the change of the gasoline spot market price as focal point. However, in this situation the

[4] Formally, the German Aral website does not mention suggested prices, but "Durchschnittspreise" (average prices). However, this listed price has a common effect since this price is commonly observable and is changed every day at 08.00 hours.

[5] Recently oil companies in Italy decided not to publish suggested prices anymore after an investigation of the Italian competition authority (see Autorità Garante della Concorrenza e del Mercato, press release number 5/2007 (I681 - Retail fuel prices (start of investigation)) and press release number 92/2007 (Fuel: oil companies' commitments accepted)).

[6] See, e.g., www.bp.nl for the Netherlands and www.aral.de for Germany.

[7] In other sectors where quality in presale service is important, a rationale for suggested prices may be to prevent firms to free ride on other firm's service provision. This reason is not important in the gasoline sector since pre-sale service is not important because gasoline is a perfectly homogeneous good.

suggested price is not necessarily harmful for consumers since the spot market price is already public information and a clear alternative focal point because it is the (major) variable cost for a liter of gasoline. As a consequence, if suggested prices just contain changes in the spot market price, then suggested prices do not provide additional coordination possibilities compared to the situation without suggested prices. Note that this is different in most other markets (such as the psychologists mentioned before) where a clear alternative focal point does not exist.[8]

The main question this chapter addresses is whether changes in suggested prices just conveniently summarize changes in the common input price, or whether they have an additional coordinating effect on prices.[9] In other words: does a suggested price provide additional coordination possibilities compared to the situation without suggested price? An additional issue we address is the role of multiple suggested prices. In the gasoline market, most of the larger oil companies set their own suggested price. We can thus distinguish between a general, across brand, influence of suggested prices on retail prices and a brand-specific effect.

To analyze these questions, we use panel data techniques on a Dutch data set consisting of daily retail prices of (almost) all gasoline stations over the period 30 May 2006 – 20 July 2008 and daily suggested prices of the five largest oil companies. We find that retail prices can be explained by information in suggested prices that is not contained in the international spot market price. Our main conclusion is that suggested prices have a coordinating effect, both across brands and within brands.

The main question that follows is how to interpret our empirical finding. One possibility is that suggested prices co-determine the cost at which retailers buy their gasoline so that

[8] Another difference with many other markets is that in the gasoline sector input prices change rapidly.

[9] Another study that quantifies the impact of focal points on price coordination is Knittel and Stango (2003). This paper studies government imposed nonbinding price ceilings in the American credit card market. Foros and Steen (2008) study Norwegian gasoline prices and find weekly price cycles. They argue that the suggested price and retail price are related on the first day of a cycle.

retailers merely react to changes in their (opportunity) cost. A second interpretation is that this is not the case and that retailers use the suggested price as a device for coordination and that their cost levels are not affected. As the main daily change in the cost of the distribution chain as a whole (the oil company and gasoline station together) is the change in the international spot market price and as this price is not affected by the suggested price in the Netherlands, the difference between the two interpretations mainly is with respect to the issue who benefits from the suggested price, the oil companies or the retailers. A third possibility is that oil companies adjust the suggested price as a reaction to foreseeable changes in demand. In this interpretation neither the oil companies nor the retailers benefits from the suggested price. As we do not have information on the cost of gasoline for individual gasoline stations or on the daily quantities sold, we can only perform indirect tests discriminating between the three interpretations. Our indirect tests suggest that the third interpretation is unlikely to explain our empirical finding and that the second interpretation is more likely than the first.

The rest of the chapter is organized as follows. Section 2.1 describes the gasoline market in the Netherlands, the different types of gasoline stations that exist, and the way suggested prices are communicated. Section 2.2 provides details on the data set and some descriptive statistics. Section 2.3 discusses the equation we estimate and Section 2.4 presents the main results. Section 2.5 considers the three alternative interpretations for our empirical finding. Section 2.6 concludes and provides a discussion.

2.1 The Dutch gasoline market[10]

There are around 4,300 gasoline stations in the Netherlands with the five largest oil companies (BP, Esso, Shell, Total, and Texaco) having a total market share of around 70% (measured as the total number of stations using the "flag" of these five companies divided

[10] If not noted otherwise, most data given in this section are based on BOVAG (2006).

by the total number of stations). Roughly speaking there are three types of ownership models: some stations (including almost all the larger stations along highways) are company-owned and company-operated (coco), other stations are company-owned and dealer-operated (codo), and the remaining stations are dealer-owned and dealer-operated (dodo). Coco stations are not free to set their own gasoline prices: these prices are set at the central company level. Dealers of codo stations rent the station from the oil company, participate in the company's sales and loyalty programs, but are free to set their own prices. Finally, dodo stations operate most independently from the larger oil companies, although even these stations have to buy the gasoline they sell from the oil company. Approximately 60% of the stations are dealer-owned. We do not know exactly how many stations are dealer-operated, but rough estimates indicate that this percentage is 80%.

Gasoline prices in the Netherlands are among the highest in Europe. One may quote several reasons for these high retail prices. First, excise duty and VAT account for approximately 60% of the retail price of a liter Euro95 and are in absolute terms among the highest taxes in Europe. Second, the Netherlands has a very dense network of highways and accordingly a relatively high percentage of the total number of gasoline stations is located along the highway (more than 5% compared to a number slightly above 1% in France and the UK). It is known that highway users are less price sensitive than other drivers. Finally, almost no supermarket chain has the permission to sell gasoline in the Netherlands.[11] In countries such as France, and to a smaller extent the UK, supermarkets tend to play the role of price fighters encouraging price competition on a wider scale.

Euro95 and Diesel are the most important gasoline products. Of all liters of sold gasoline products, roughly 38% are Euro95 and 54% are Diesel. Euro95 is most commonly used by private users and Diesel is most commonly used for leased cars and trucks. The total volume of sales seems to have stabilized in recent years with total kilometers still rising

[11] 0.9% of all gasoline volume sold in the Netherlands is sold via a supermarket, whereas this number is 54% and 29% for France and the UK, respectively.

slightly, but this effect is compensated by the use of more energy efficient vehicles. The use of LPG has declined over the years.

The larger oil companies have suggested prices that they determine on a daily basis. Oil companies differ in the way they make their suggested prices public. Some publish their suggested prices on their website (BP, Total, and many smaller oil companies), others do not publish suggested prices (Esso, Shell, and Texaco).[12] Nevertheless, all these suggested prices are publicly available since they are published every day on the websites of the ANWB (the Dutch automobile club with almost 4 million members) and United Consumers.[13]

The suggested prices of different oil companies do not seem to be very different from one another. In practice, the suggested price acts as a reference price. Dealer-operated stations decide whether to give a "discount" compared to this daily price. Stations along the highway usually follow the suggested prices exactly, whereas nonhighway stations give discounts more frequently. Gasoline stations advertise this discount explicitly (and often not the real price) as a price discount with reference to the suggested price (whatever the level of that price may be).

Shell (the largest oil company) has explicitly claimed in the past that it uses the suggested price as a way to make gasoline spot market price changes transparent to its dealers. It also published detailed descriptions on how it calculates the suggested price (see, e.g., Shell (2001) and the Shell website). Shell claims that every morning it takes the spot market price of the previous day (which is the most recent price available) and adds different taxes and margins (for transport, sales costs, etc.) to come up with a price it thinks gasoline stations should charge for their gasoline. If this price is different from the current suggested price, a pricing committee meets to determine whether it changes the suggested

[12] Shell published suggested prices on its website until 15 March 2006.

[13] This latter site also links the prices to other websites like the website of a car magazine and www.nu.nl, a Dutch news website (the tenth most visited website in the Netherlands). See www.anwb.nl and www.unitedconsumers.com.

price and by how much. If the price change is decided, the new price (which is valid from the next day onward) is communicated via fax and e-mail to all dealers in the evening. Dealers can then update their prices the next morning. If this decision process is indeed followed, the delay between changes in the gasoline spot market price and prices at stations is exactly two days.

The input prices for gasoline are closely related to the international market for the respective inputs. Although the large oil companies are fully integrated from extracting oil to selling gasoline, the Dutch gasoline sales divisions mainly buy their gasoline on the Amsterdam-Rotterdam-Antwerp (ARA) spot market which supplies large parts of western Europe. Shell claims that even if the Dutch sales division buys gasoline from a production division, this spot market price is used as internal price.[14]

2.2 Data description and first results

Dutch gasoline retail prices are published daily on the webpage of Athlon Car Lease.[15] This company leases cars to other firms including a so-called "fuel card". If the driver fills up his car, he shows the card to the gasoline station and the retailer electronically sends the bill with price and quantity information to the lease company at the same time. As a result, Athlon Car Lease obtains gasoline price notations from 120,000 drivers, who fill up on average twice a week, from all over the Netherlands. Athlon Car Lease puts the data on gasoline prices on its website and we have downloaded the data daily over the period 30 May 2006 – 20 July 2008. As indicated in the previous section, there are approximately 4,300 gasoline stations in the Netherlands, of which over 3,600 are included in this data set. Stations that are not included in the data set seem to be mostly smaller and nonactive stations randomly distributed over the country. Data are available for seven different kinds

[14] www.shell.nl

[15] www.athloncarlease.nl

of gasoline: Euro95, Diesel, Super, Super Plus, Special Euro95, Special Diesel, and untaxed Diesel. Since the normal versions of Euro95 and Diesel are most commonly used, we focus our analysis on these two types. Per day we have in total approximately 6,000 unique station-gasoline type-price quotations.[16] Note that we have for each station-gasoline type combination a maximum of one price quotation per day. Since less busy stations have a lower probability of being visited by a driver of a car leased from Athlon Car Lease, the data set contains more quotations of busier stations. This does not have an impact on our analysis, however, as there is no indication that pricing decisions of larger gasoline stations differ significantly from that of smaller ones (after correction for ownership structure). It is also of importance to note that drivers do not have to pay for the gasoline (as the firm that employs the driver does). So more expensive stations are not avoided by these drivers. Casual observation shows that cheaper stations are not avoided either.

We matched individual stations in the data set to lists of individual characteristics of gasoline stations, namely owner and brand of a station and whether a station is located along a highway.[17] [18] We do not have data on the operator of a station, but we do know the ownership structure. This means that we are able to filter out stations where an oil company decides on the price.

We downloaded the suggested prices from the United Consumers website during the sample period. This website contains daily suggested prices of the five largest oil companies for eleven different types of gasoline (some types are brand specific). The spot market notation we use is the daily Platt's Barges FOB Rotterdam High (series: Premium Gasoline 10 PPM for Euro95 and Diesel 10 PPM for Diesel). Shell uses the same notation for calculating the suggested price (Shell (2001)).

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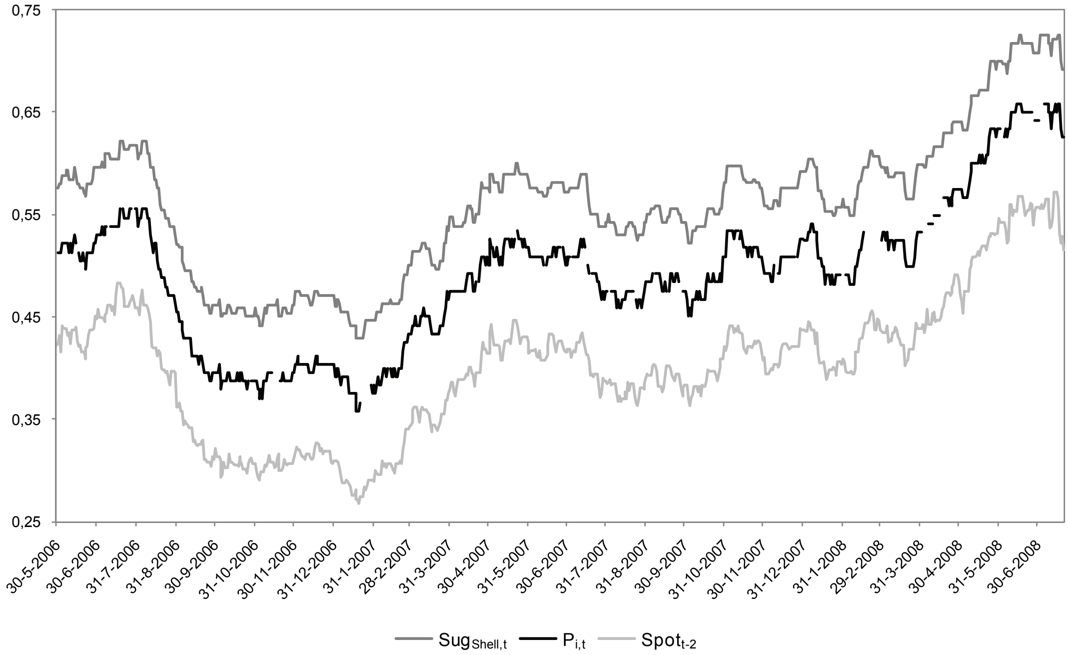
[16] Over the whole data set, only a couple of observations are suspicious. These seem to be cases where a certain type of gasoline is reported as another kind of gasoline. We have deleted these quotations.

[17] We obtained lists with the ownership structure and brand of a station from Catalist (a company collecting data on gasoline stations) and a list with highway stations from the Dutch Ministry of Finance.

[18] It may be that stations change their brand or ownership structure during the sample period. As we do not have information on this, we assume that stations do not change their brand and ownership structure.

Figure 2.1 Shell suggested price, retail price of a representative Shell station, and spot market price for one liter Euro95



Notes: T=783, price in euro per liter (excluding excise duty and VAT).

The dollar-euro exchange rate and data on taxes are obtained via the websites of respectively the European Central Bank and the Dutch Ministry of Finance. We converted all prices to price per liter (*excluding taxes*) in euros.

2.2.1 A first look at the data

Figure 2.1 shows the development over time of the two-day lagged spot market price, the retail price of a representative Shell station, and the Shell suggested price for one liter Euro95 during the sample period. Figure 2.A1 in Appendix 2.A shows the same data for Diesel.

For illustration purposes, we plot some figures with Euro95 prices over the last 100 days of the sample. Figure 2.2 shows the difference between the retail price and the Shell suggested price for four selected dealer-owned Shell gasoline stations. Figure 2.3 shows the difference between the retail price of the same four gasoline stations and the two-day lagged spot market price. Taken together, Figure 2.2 and 2.3 show that the difference between the suggested price and the retail price is more stable than the difference between the retail price and the spot market price. This suggests that the prices of these four gasoline stations contain information from the Shell suggested price that is not present in the spot market price.

We are interested in whether suggested prices have a coordinating effect across different brands. This occurs if the correlation between suggested prices of different oil companies is stronger than the correlation of each one of them with the two-day lagged spot market price (and retailers follow suggested prices). Figure 2.A2 in Appendix 2.A shows the difference between the suggested price and spot market price for all five oil companies. The figure shows that oil companies often put the same additional information in their suggested prices. Over the whole sample, the suggested price of at least four (or *all* five) oil companies differs in exactly the same way from the two-day lagged spot market price on 61% (32%) of the days. So it seems that there is a strong common component in the suggested prices. This explains why suggested prices may have a coordinating effect across brands.

Figure 2.4 shows the difference between the retail price of the four selected Shell stations and the average of the suggested prices of the other four oil companies. Figure 2.3 and 2.4 show that the difference between the retail price and the average suggested price is more stable than the difference between the retail price and the spot market price. This suggests an across brand coordinating effect. In combination with Figure 2.2, Figure 2.4 shows that the difference between the retail price and the Shell suggested price is more stable than the difference between the retail price and the average suggested price. Thus, the Shell

Figure 2.2 Retail price - Shell suggested price (Euro95, for four Shell stations)

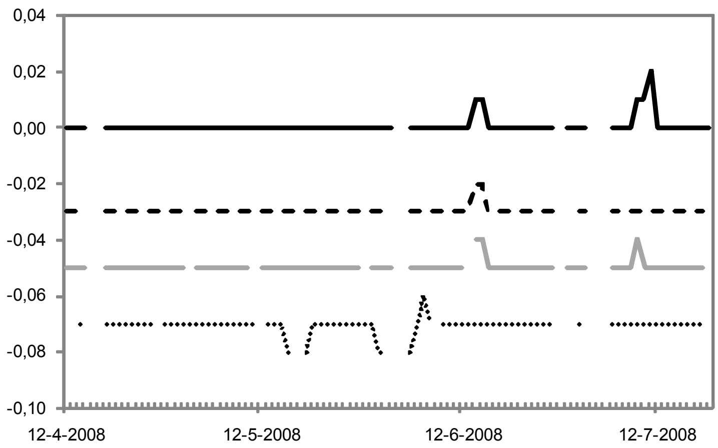


Figure 2.3 Retail price - spot market price (Euro95, for four Shell stations)

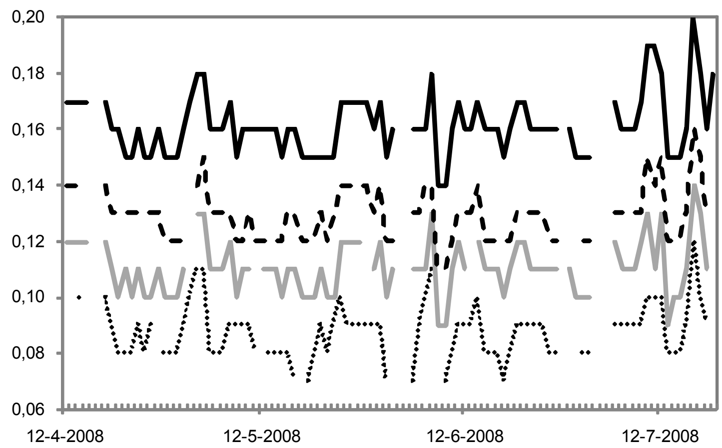
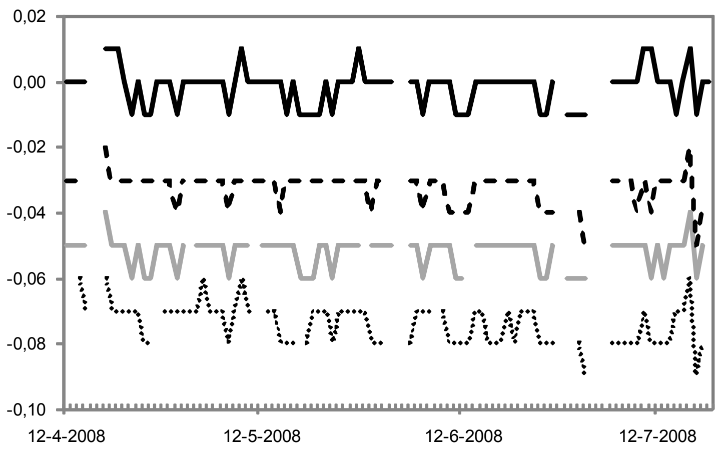


Figure 2.4 Retail price - average of suggested prices of the four other brands (Euro95, for four Shell stations)



suggested price explains the retail price of the selected Shell stations better, suggesting a within brand coordinating effect. We will study these observations in a more structured way in Section 2.3 and 2.4.

2.3 Methodology

As explained in the introduction, our purpose is to study whether the existence of suggested prices has an additional coordinating effect on retail prices compared to the situation without suggested prices (i.e., the situation where only the spot market price is public information). This additional coordinating effect exists if there is, next to the spot market price, additional information in suggested prices that appears in retail prices as well.

We divide the suggested price of an oil company into three parts: i) the spot market price, ii) a common component that is, next to the spot market price, introduced by all oil companies in their suggested price, and iii) a brand-specific part which is only present in the suggested price of this oil company. We test which parts of the suggested price are present in retail price changes.[19]

Whether the existence of suggested prices has a coordinating effect on retail prices, depends on the part of the suggested price that has an impact on retail price changes. If changes in retail prices only reflect changes in the part of the suggested price that represents the spot market price, then suggested prices do not have an *additional* coordinating effect compared to the situation without suggested prices. The spot market price could also have this coordinating effect if suggested prices would not exist. If changes in retail prices reflect changes in the common part of the suggested prices, then

[19] We focus on the coordinating effect of suggested prices on price changes (and not on price levels). Although the best alternative focal point for changes is obvious (the spot market price), this is not the case for levels. As a result, we cannot formulate a hypothesis on what would happen to levels in a situation without suggested prices.

suggested prices have a coordinating effect on retail prices across stations of all brands (since in this case all retail prices change in the same way, but in a different way than the spot market price). Finally, if changes in retail prices reflect changes in the brand-specific part of the suggested price, then suggested prices cause a coordinating effect between stations that carry the same brand (since in this case retail prices of stations with the same brand change in the same way).

We model the relation between the retail price and the three different parts of the suggested price via a conditional error correction model:

$$\Delta P_{i,t} = \sum_{k=1}^{q} \alpha_k \Delta P_{i,t-k} + \sum_{k=0}^{r} \beta_k \Delta Spot_{t-2-k} + \sum_{k=0}^{r} \gamma_k \Delta(\overline{Sug}_{-i,t-k} - Spot_{t-2-k})$$

$$+ \sum_{k=0}^{r} \lambda_k \Delta(Sug_{i,t-k} - \overline{Sug}_{-i,t-k}) + \phi_1 [P_{i,t-1} - Spot_{t-3}]$$

$$+ \phi_2 [P_{i,t-1} - \overline{Sug}_{-i,t-1}] + \phi_3 [P_{i,t-1} - Sug_{i,t-1}] + \eta_i + \varepsilon_{i,t} \qquad (2.1)$$

where $P_{i,t}$ is the retail price of one liter of gasoline at station *i* on day *t*, $Spot_{t-2-k}$ is the gasoline spot market price on day *t*-2-*k*, $\overline{Sug}_{-i,t-k}$ is the average of the suggested prices of all oil companies other than the oil company of the brand of station *i* on day *t*-*k*, and $Sug_{i,t-k}$ is the suggested price of the oil company of station *i* on day *t*-*k*.[20] Finally, η_i is a station-specific effect and $\varepsilon_{i,t}$ is the error term which is allowed to be heteroskedastic (both across stations and time), serially correlated, and cross-sectionally correlated (contemporaneous and lagged).[21] All prices are measured in euro per liter and are

[20] We choose a linear relationship instead of a log specification because the data show that the absolute difference between retail prices, suggested prices, and the spot market price is stable and independent of the level of the spot market price (see also Borenstein, Cameron, and Gilbert (1997)).

[21] Contemporaneous correlation might, for example, exist because of errors in the suggested price data. If all stations use their oil companies' suggested price and if there is an error in the data for the suggested price for a certain oil company on a certain day, stations with that brand will all deviate from the predicted price in the same manner.

excluding excise duty and VAT. As mentioned before in Section 2.1, we delay the spot market price with two days, since this is the relevant input price for the suggested price.[22]

First, we motivate why we choose a conditional error correction model. All four price series ($P_{i,t}$, $Spot_{t-2}$, $\overline{Sug}_{-i,t}$, and $Sug_{i,t}$) are integrated of order 1.[23] From Figure 2.1, it seems that there is one single stochastic trend driving the four price series. In fact, given the strict order in which the prices are set, it seems appropriate to consider the spot market price as the underlying stochastic trend. In other words, there seem to be three stationary cointegrating relations between these four price series. These three linear combinations of price series are not uniquely defined, but can be expressed in many ways. Therefore we choose an expression that is easy to interpret. Our single-equation approach is appropriate due to again the strict order in which the prices are set (retail prices follow suggested prices and not vice versa). Endogeneity issues between retail prices and the other variables are not important, i.e., the explaining variables are really exogenous with respect to retail prices.

Second, we explain how to interpret Equation (2.1). In Equation (2.1) the change in the retail price depends on the previous change in the retail price, the current (and previous) change in the different parts of the suggested price, and the error correction terms. We first discuss the direct impact of changes in the different parts of the suggested price on retail price changes. In Equation (2.1) the second term denotes the part of the suggested price that reflects spot market price changes. The variable $\overline{Sug}_{-i,t-k}$ proxies the information that is common in all suggested prices. So the third term, $(\overline{Sug}_{-i,t-k} - Spot_{t-2-k})$, is a proxy for the information that all oil companies put in their suggested price over and above the spot market price (the second part of the suggested price). If the coefficients γ are positive and

[22] The suggested price has the highest correlation with the spot market price if we use a two-day lag.

[23] Augmented Dickey-Fuller unit root tests indicate that the two-day lagged spot market price, the suggested prices of the five oil companies, and the averages of the suggested prices are integrated of order 1 (for both Euro95 and Diesel). Augmented Dickey-Fuller Fisher panel unit root tests (Maddala and Wu (1999), Choi (2001)) indicate that both Euro95 and Diesel retail prices are integrated of order 1. Augmented Dickey-Fuller unit root tests on individual price series of gasoline stations indicate that 98% of both Euro95 and Diesel price series are integrated of order 1. We treat all Euro95 and Diesel price series as integrated of order 1.

significant, retail price changes contain information that is present in the suggested prices of all oil companies and that is additional to the spot market price. In that case suggested prices have a coordinating effect across all stations. Finally, the fourth term, $(Sug_{i,t-k} - \overline{Sug}_{-i,t-k})$, reflects the third part of the suggested price and proxies the information that is only present in the suggested price of the oil company of station i and not in the suggested prices of other oil companies. If the parameters λ are positive and differ significantly from zero, then suggested prices have a coordinating effect on retail prices of stations with the same brand.

The error correction terms are the terms between square brackets and define the long-run or "equilibrium" relationships between the retail price and the other three price series. From an economic perspective, it seems reasonable to assume that the cointegrating relations can be specified as the difference between two price series (see also Footnote 20). In the long run, changes in the underlying stochastic trend of the three price series (which is the spot market price) should be fully reflected in retail prices. Moreover, if we do estimate the long-run impact of $Spot_{t-3}$, $\overline{Sug}_{-i,t-1}$, and $Sug_{i,t-1}$ on $P_{i,t-1}$, we find that their coefficients almost equal 1 (see also Table 3.A2 and 3.A3).[24] The parameters ϕ show to what extent retail price changes are influenced by deviations in the equilibrium relation between the retail price and respectively the spot market price, the information that is common in all suggested prices, and the brand-specific suggested price. Differences between the parameters ϕ show of which long-run relation the deviations have the largest impact on retail price changes.

We estimate Equation (2.1) two times; once for our subsample of Euro95 prices and once for our subsample of Diesel prices. Our sample only contains stations with the brand of one of the five largest oil companies, since for these stations we have data on brand-specific suggested prices. For both estimations we mainly use the data we have on dodo stations, as

[24] The panel cointegration test of Kao (1999) reveals homogeneous cointegration between retail prices and the two-day lagged spot market price, the information that is common in all suggested prices, and brand-specific suggested prices (for both Euro95 and Diesel).

these are the stations that are completely free to determine their own prices.[25] We use the Ordinary Least Squares (OLS) Within estimator.[26] Moreover, we use Driscoll-Kraay standard errors that are robust to heteroskedasticity, serial correlation, and cross-sectional correlation (see Driscoll and Kraay (1998) and also Hoechle (2007)).

2.4 Results

Table 2.1 contains the estimation results for Euro95. The first column shows the estimation results of Equation (2.1) with q=0 and r=0. Our sample contains all dealer-owned gasoline stations that have the brand of one of the five largest oil companies.

The table shows that the coefficient for the immediate impact of the part of the suggested price that reflects the spot market price equals 0.88.[27] So a change in this part of the suggested price is largely reflected in the change of the retail price. However, we also find a strong impact of the part of the suggested price that reflects the information that is, next to the spot market price, common in the suggested prices of all oil companies. The coefficient of this term is, with a value of 0.83, quite substantial and highly significant. This indicates that the common component of the suggested prices contains additional information that explains retail prices over and above the fluctuations in the spot market price. The additional information in the brand-specific suggested price, the third part of the suggested price, is also important for explaining the retail price. The value of the

[25] Retail prices are not available for all stations for all days. We can only use an observation of a station's retail price for estimation when the previous q+1 observations of this station are also available.

[26] Although this estimator is inconsistent for dynamic models if the number of observations over time is fixed (even if the number of groups go to infinity), it is consistent if the number of observations over time also go to infinity. Our data set contains many stations over a relatively long period (783 days), so using the OLS Within estimator should not be a problem.

[27] The coefficients of the different parts of the suggested price differ from the effective coefficients of the variables. For example, the effective coefficient for the direct impact of the spot market price is 0.05 (0.88 -0.83). This shows that suggested prices contain most of the information in the spot market price that is also present in retail prices.

coefficient is 0.67. So retail prices also contain information that is only present in the brand-specific suggested price.

All estimated parameters ϕ are negative, which indicates that in all three cases when the retail price deviates from what the equilibrium relation implies, the retail price is corrected in the direction of the equilibrium retail price. However, the estimated values of the parameters ϕ_1 and ϕ_2 are close to 0 (both are -0.04), while the estimated value of ϕ_3 is -0.21. This shows that retail prices respond mostly to deviations in the long-run relation between the retail price and the brand-specific suggested price. Deviations in the long-run relation between the retail price and the spot market price and between the retail price and the common information in all suggested prices are less important for explaining retail price changes.

The second column of Table 2.1 depicts the estimation results of Equation (2.1) with q=3 and r=3. Our estimates are robust to changes in the lag specification. Again, changes in the part of the suggested price that reflects the spot market price are important for explaining changes in retail prices, but so are the parts that represent the common component of the suggested prices and the brand-specific component. Also the estimation results concerning the long-run relations confirm our previous findings. Table 2.A1 in Appendix 2.A shows that estimation results are similar for Diesel.

These results indicate that the part of the suggested price that is, next to the spot market price, common in all suggested prices and the part that is brand-specific are important for explaining retail prices in addition to the part that reflects the spot market price. Retail prices contain all three parts of the suggested price. Therefore, we conclude that the existence of suggested prices causes a coordinating effect across stations with different brands. Moreover, there also exists an additional coordinating effect between stations with the same brand.

Table 2.1 Estimation results Euro95

	Equation (2.1)	
	q=0, *r*=0	*q*=3, *r*=3
Sample	DO & Brand	DO & Brand
$\Delta P_{i,t-1}$		-0.39 (0.01)
$\Delta P_{i,t-2}$		-0.25 (0.01)
$\Delta P_{i,t-3}$		-0.13 (0.01)
$\Delta Spot_{t-2}$	0.88 (0.01)	0.92 (0.01)
$\Delta Spot_{t-3}$		0.37 (0.02)
$\Delta Spot_{t-4}$		0.25 (0.01)
$\Delta Spot_{t-5}$		0.13 (0.01)
$\Delta(\overline{Sug}_{-i,t} - Spot_{t-2})$	0.83 (0.01)	0.87 (0.02)
$\Delta(\overline{Sug}_{-i,t-1} - Spot_{t-3})$		0.36 (0.02)
$\Delta(\overline{Sug}_{-i,t-2} - Spot_{t-4})$		0.25 (0.02)
$\Delta(\overline{Sug}_{-i,t-3} - Spot_{t-5})$		0.13 (0.02)
$\Delta(Sug_{i,t} - \overline{Sug}_{-i,t})$	0.67 (0.02)	0.69 (0.02)
$\Delta(Sug_{i,t-1} - \overline{Sug}_{-i,t-1})$		0.27 (0.02)
$\Delta(Sug_{i,t-2} - \overline{Sug}_{-i,t-2})$		0.19 (0.02)
$\Delta(Sug_{i,t-3} - \overline{Sug}_{-i,t-3})$		0.10 (0.01)
$(P_{i,t-1} - Spot_{t-3})$	-0.04 (0.01)	-0.04 (0.01)
$(P_{i,t-1} - \overline{Sug}_{-i,t-1})$	-0.04 (0.01)	-0.02 (0.01)
$(P_{i,t-1} - Sug_{i,t-1})$	-0.21 (0.01)	-0.11 (0.01)
Observations	372,450	219,221
Stations	1,176	970

Notes: T=783, Driscoll-Kraay standard errors between brackets (lag length considered in the serial correlation structure determined via Newey-West procedure (6 lags in case of q=0, r=0 and 5 lags in case of q=3, r=3)). Station-specific effects are not reported. DO = dealer-owned stations, Brand = stations with the brand of one of the five largest oil companies. Note that the reported number of stations may not be exactly identical to the number of physical stations (some gasoline stations change their name during the sample period and we do not merge the series of these stations).

2.4.1 Robustness

We check the robustness of our results by estimating alternative specifications. All of these specifications underline the important qualitative aspects of the results reported so far. We report some of these robustness checks. First, we estimate the equation for all company-owned gasoline stations with the brand of one of the five largest oil companies. These are the gasoline stations which are not (or possibly not completely) free to deviate from the suggested prices as set by the oil companies. The first column of Table 2.2 contains the estimation results of Equation (2.1) with q=0 and r=0 for Euro95. The estimated coefficients are similar to those of the group of dealer-owned stations. This shows (what was to be expected) that also for company-owned gasoline stations the part of the suggested price that is common in all suggested prices and the part that is brand-specific are important for explaining retail prices in addition to the part that reflects the spot market price.

Second, we estimate the equation for subsamples of our population of dealer-owned gasoline stations with the brand of one the five largest oil companies to take into account possible heterogeneity of stations. To this end, we group gasoline stations based on location (highway or nonhighway) and brand. Table 2.2 contains for each of these respective cases the estimation results of Equation (2.1) with q=0 and r=0 for Euro95. The second and third column show estimation results for respectively stations that are located along a highway and stations that are not located along a highway. In both cases, we confirm the general conclusion that changes in retail prices reflect changes in all three parts of the suggested price. In the lower part of Table 2.2 the gasoline stations are grouped by brand. It shows that for some brands the coefficient that measures the impact of the brand-specific part of the suggested price is larger than for other brands.[28]

[28] We perform the same robustness checks as reported in Table 2.2 for our subsample of Diesel observations. The results are not reported here as their qualitative conclusions are similar to the conclusions of the checks reported in Table 2.2.

Table 2.2 Robustness of estimation results Euro95

	Equation (2.1) q=0, r=0		
Sample	CO & Brand	DO & Brand & Highway	DO & Brand & Nonhighway
$\Delta Spot_{t-2}$	0.92 (0.01)	0.90 (0.01)	0.88 (0.01)
$\Delta(\overline{Sug}_{-i,t} - Spot_{t-2})$	0.87 (0.01)	0.85 (0.02)	0.83 (0.01)
$\Delta(Sug_{i,t} - \overline{Sug}_{-i,t})$	0.73 (0.02)	0.60 (0.02)	0.67 (0.02)
$(P_{i,t-1} - Spot_{t-3})$	-0.03 (0.00)	-0.03 (0.01)	-0.04 (0.01)
$(P_{i,t-1} - \overline{Sug}_{-i,t-1})$	-0.04 (0.01)	-0.12 (0.02)	-0.04 (0.01)
$(P_{i,t-1} - Sug_{i,t-1})$	-0.15 (0.01)	-0.25 (0.02)	-0.21 (0.01)
Observations	579,202	17,265	355,185
Stations	1,093	40	1,136

	Equation (2.1) q=0, r=0				
Sample	DO & Brand A	DO & Brand B	DO & Brand C	DO & Brand D	DO & Brand E
$\Delta Spot_{t-2}$	0.91 (0.02)	0.83 (0.02)	0.92 (0.01)	0.85 (0.02)	0.83 (0.01)
$\Delta(\overline{Sug}_{-i,t} - Spot_{t-2})$	0.85 (0.02)	0.75 (0.02)	0.87 (0.02)	0.84 (0.03)	0.81 (0.01)
$\Delta(Sug_{i,t} - \overline{Sug}_{-i,t})$	0.64 (0.04)	0.50 (0.04)	0.85 (0.02)	0.57 (0.05)	0.65 (0.02)
$(P_{i,t-1} - Spot_{t-3})$	-0.06 (0.01)	-0.07 (0.01)	-0.05 (0.01)	0.03 (0.01)	-0.01 (0.01)
$(P_{i,t-1} - \overline{Sug}_{-i,t-1})$	-0.05 (0.02)	-0.12 (0.02)	0.03 (0.01)	-0.11 (0.03)	-0.06 (0.02)
$(P_{i,t-1} - Sug_{i,t-1})$	-0.24 (0.02)	-0.09 (0.02)	-0.26 (0.02)	-0.18 (0.02)	-0.24 (0.02)
Observations	58,286	67,141	128,014	64,096	54,913
Stations	144	190	282	270	290

Notes: T=783, Driscoll-Kraay standard errors between brackets (lag length considered in the serial correlation structure determined via Newey-West procedure (6 lags)). Station-specific effects are not reported. CO = company-owned stations, DO = dealer-owned stations, Brand = stations with the brand of one of the five largest oil companies. Note that the reported number of stations may not be exactly identical to the number of physical stations (some gasoline stations change their name during the sample period and we do not merge the series of these stations).

We also estimate an alternative version of Equation (2.1) by replacing the average suggested price by the Shell suggested price (as Shell is considered by some to be the price leader in the Dutch gasoline market). These estimations provide similar results as the equation using the average suggested price. The information in the brand-specific suggested prices that is additional to the Shell suggested price is important for explaining retail prices of gasoline stations with the brand of one of the four other oil companies.

2.5 Alternative interpretations

In the previous section we have shown that suggested prices have a coordinating effect in the sense that they contain information that helps to explain retail prices in addition to the international spot market price for gasoline. This is, however, not necessarily a sign that retailers coordinate their pricing decisions using the suggested price as a means. There are two alternative interpretations. A first alternative is that retailers buy gasoline at a cost that depends on the suggested price or that the suggested price influences the opportunity cost of retailers. If this is the case, then retail prices do depend on suggested prices through their impact on (opportunity) costs of retailers. A second alternative is that oil companies react to the changes they observe (or foresee) in demand and that they inform retailers by adjusting the suggested price. As we do not possess data on the (daily changes in the) cost of retailers and as we also do not have access to data on daily quantities sold, we have to rely on other, more indirect ways to discriminate between the three interpretations.

2.5.1 Demand interpretation

We first consider the demand interpretation as this is conceptually the easiest to deal with. The day of the week seems to be an important (and predictable) determinant for changes in demand. The first row of Table 2.3 shows the daily change in the total amount of kilometers driven by cars in the Netherlands per day. The table shows that people drive much less during the weekend than during weekdays, especially on Sundays. As a result, people drive 45% more kilometers on Mondays compared to Sundays. We conjecture that the kilometers driven are a good proxy for the liters of gasoline sold. It is hard to imagine any other demand factor that has a stronger impact on changes in demand on a day-to-day basis.

This weekly pattern in demand has, however, only a very limited effect on the pricing behavior of oil companies and gasoline stations. On the basis of our data set, we calculate for each day of the week the average percentage of oil companies that change their suggested price. The second row of Table 2.3 shows the results: oil companies rarely change their suggested price on Mondays and never on Sundays (possibly, because these suggested prices should have been calculated on Saturdays and Sundays, see Section 2.1). Changes in suggested prices are much more common on other days. We also calculate for each day of the week the average percentage of gasoline stations that change their retail price. The third row in Table 2.3 shows that on Mondays only 18% of the gasoline stations change their price and on Sundays only 17%. On other days of the week, this average percentage is much higher (around 40%) and in line with the frequency with which suggested prices change.

If oil companies would change their suggested prices in view of daily changes in demand, then one would expect that suggested prices change much more often on Saturdays, Sundays, and especially Mondays than on other days of the week. This is, however, not the case as is evident from Table 2.3. We therefore conclude that it is unlikely that the demand interpretation can explain our results.[29]

[29] We also perform additional econometric estimations in which we explain the information in suggested prices that is additional to the spot market price by day dummies. Day dummies can only explain a negligibly small part of the additional information in the suggested price (of all estimated specifications the highest R^2 is 0.029).

Table 2.3 Daily changes in kilometers driven and prices

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Change in kilometers driven	-21%	45%	4%	3%	3%	0%	-21%
Percentage of oil companies that change suggested price	0%	4%	39%	42%	33%	38%	45%
Percentage of gasoline stations that change retail price	17%	18%	40%	42%	37%	44%	46%

Notes: The source for data on kilometers driven is CBS Statline (data for 2007). Calculations are for Euro95. Results for Diesel are similar.

2.5.2 Cost interpretation

The cost interpretation is conceptually more difficult as we have to distinguish between accounting cost and opportunity cost. On the other hand, it may also be less far reaching in the following sense. We have observed in the previous section that suggested prices contain information over and above the international spot market price and that this information is present in retail prices. If suggested prices do not have an impact on the accounting cost or opportunity cost of a gasoline station, then gasoline stations use suggested prices to coordinate their pricing decisions. If, on the other hand, the relevant notion of cost does depend on suggested prices, then oil companies use suggested prices to coordinate their wholesale prices. The fact that either one or the other conclusion should be drawn, is because the additional information that suggested prices contain can certainly not be explained by daily fluctuations in the cost of Dutch oil companies (which is the spot market price) as the Netherlands is a small player in the international market. Thus, the question whether suggested prices have an impact on the relevant cost level of retailers is just a question of who benefits from suggested prices.

What follows are more interpretative comments on whether retailers use the suggested price to coordinate their pricing decisions independent of cost changes. Regarding accounting cost, we know that on a particular day only a limited number of gasoline stations buy new gasoline, while most gasoline stations use the additional information in the suggested price on that day. According to an industry source (Beta, the organization for independent gasoline retailers) many stations are supplied with new stock three times a week.[30] Naturally, there are important differences between stations.[31] This means that each day on average 43% (3/7) of the gasoline stations get new stock. We also know the dates at which the suggested prices change and also that these dates are independent of the delivery moments of new gasoline to stations. As a consequence, if the cost of a liter of gasoline depends on the suggested price and if gasoline stations simply adjust their retail price to this cost level, we expect that only 43% of all gasoline stations will change their price when the suggested price changes (and the suggested price is not equal to the suggested price on the previous day that the gasoline stations bought new stock). The interpretation that suggested prices have a coordinating effect between retailers (i.e., gasoline stations also use the suggested price on days that they do not buy new gasoline) says that this percentage is (much) higher: it does not say that it should be 100% as this would imply that suggested prices fully coordinate retail prices and that there are no menu costs or other costs of price adjustments.

To investigate this issue further, we select all days in our data set where there is a change in a suggested price and where the suggested price of this specific brand is not equal to this suggested price on any of the days in the week before. For Euro95 there are 290 days that satisfy this restriction. For each of these days, we take the gasoline stations for which the

[30] See De Telegraaf, "Bumpersticker tegen hoge benzineprijzen" (Harry van Gelder, 4 June 2008). Other sources mention that on average gasoline stations are supplied 1.5 times per week, so that 3 times a week really seems to be an upper bound. Moreover, our conclusions do not change if we assume that gasoline stations only get new stock on working days.

[31] It is clear that the delivery pattern of a station depends on stocking capacity and turnover.

suggested price changes and calculate the percentage of stations that change their price with respect to the previous day. We restrict attention to dealer-owned stations that carry the brand of one of the five largest oil companies.

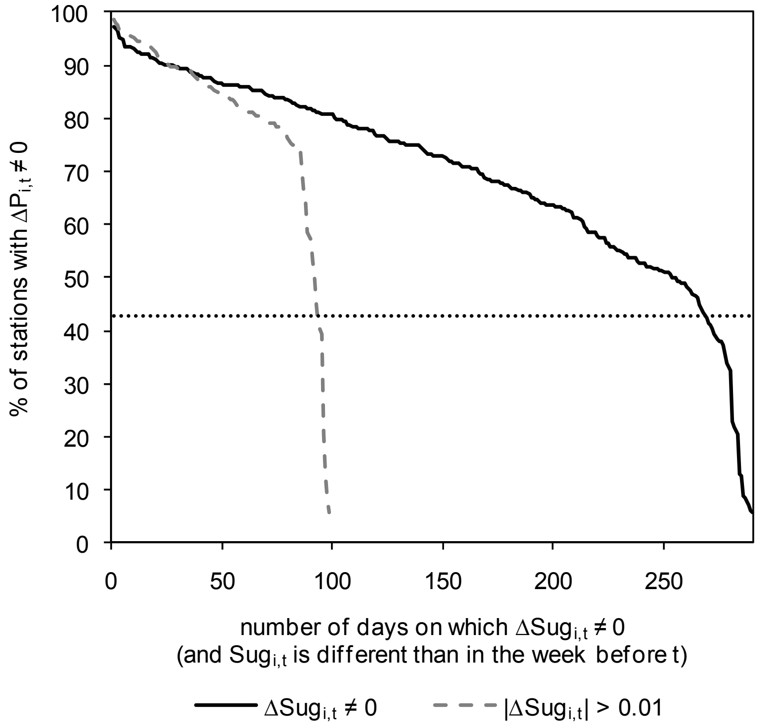
Figure 2.5 shows the percentage of stations that change their price on a certain day (for Euro95, results for Diesel are similar). For example, on 213 out of 290 days more than 60% of the stations change their price if the suggested price changes. Figure 2.5 shows that on the majority of days substantially more than 43% of the stations change their price. On only 18 out of the 290 days fewer than 43% of the stations change their price.[32] We also restrict attention to those days for which the change in the suggested price is more than 1 cent to allow for retailers not adjusting their price due to small menu costs. In this case only 99 days satisfy the restriction and the figure shows even more sharply that many more retailers use the suggested price than can be explained by accounting costs.

These results suggest that it is unlikely that the coordinating effect is fully caused by the possibility that wholesale prices depend on suggested prices. In Appendix 2.B we strengthen this conclusion by showing that most gasoline stations follow exactly the change in the suggested price on most days.

A second explanation of the cost interpretation concerns opportunity costs and the possibility that for a gasoline station these costs depend on the additional information in the suggested price. Note that for the distribution chain as a whole (the oil company and gasoline station together) the opportunity costs are equal to the spot market price and this price is independent of the additional information in the suggested price. It is not obvious what the best alternative for a gasoline station is to selling the gasoline to the current

[32] We perform a sign test to test the hypothesis that the median equals 43% against the alternative hypothesis that it is larger than 43%. For both Euro95 and Diesel the sign test rejects equality at a 1% significance level.

Figure 2.5 Percentage of stations that change their retail price on days that the suggested price changes (and the suggested price is different than in the week before)



consumer. Once the gasoline is stored in the underground tank of an individual retailer, it is very costly to do anything else with it than to sell it to consumers. In other words, the opportunity costs of selling it to a consumer are almost 0.

Alternatively, by selling a liter of gasoline to a consumer, the retailer gives up the possibility to sell the same liter to another consumer the next day or in a few days. In that case the opportunity cost of selling a liter of gasoline today equals the expected profit of selling it to a consumer in the future. However, if a gasoline station decides to sell a liter to the current consumer, it can buy and store a new liter of gasoline and still have the possibility to sell a liter in the future. In general, it seems that a retailer's best strategy is to sell to consumers that arrive first (as long as the retail price is higher than the wholesale price). Only if there is a very exceptional increase in the wholesale price on the next day, postponing seems an attractive option.[33] Furthermore, in order for such a strategy to be successful the retailer should be able to predict the wholesale price at least one day ahead.[34] Given these issues, we do not see a clear indication that the opportunity cost of the liter of gasoline depends on the current additional information in the suggested price.

We conclude that the demand interpretation is unlikely to explain our results and that of the two remaining interpretations, the interpretation that suggested prices have a coordinating effect between retailers is the most likely interpretation of our results. However, even if the latter is not true, suggested prices have a coordinating effect for the vertical chain of oil companies and retailers as a whole, as changes in the (opportunity) cost of the vertical chain are equal to changes in the international spot market price and these are unaffected by the suggested prices used in the Netherlands.

2.6 Conclusion

This chapter examines the impact of suggested prices on gasoline retail prices using a large panel data set containing almost all gasoline stations in the Netherlands. Our results show that changes in suggested prices do more than just summarizing changes in the spot market price. This is not only true for the average suggested price, but also for the brand-specific suggested price. We therefore conclude that the regime where the five largest oil companies set their own suggested price has a coordinating effect across brands and within

[33] A numerical example illustrates this intuition (numbers are rounded). According to a price decomposition on the Shell website for 5 May 2004, 63% of the difference between the retail price and spot market price reflects profit and costs for the oil company. On 31 May 2006 the spot market price is 42 cents. The average Shell retail price is 53 cents. If 63% of the difference is for the oil company, the wholesale price is 49 cents. Say that the gross margins for the gasoline station and oil company are constant. If a gasoline station buys and sells one liter on both 31 May and 1 June 2006, then it gets 8 cents in total. If the gasoline station decides not to sell on 31 May, but keeps the liter and sells it on 1 June, then the wholesale price has to rise on 1 June to 53 cents to earn 8 cents. This would equal a rise in the spot market to 46 cents (9.4%). During the sample period the maximum daily increase in the spot market price is 6.2% and the maximum daily decrease is 9.3% (second highest is a decrease of 6.5%).

[34] A retailer can have an idea about the suggested price for the next day via the current spot market price.

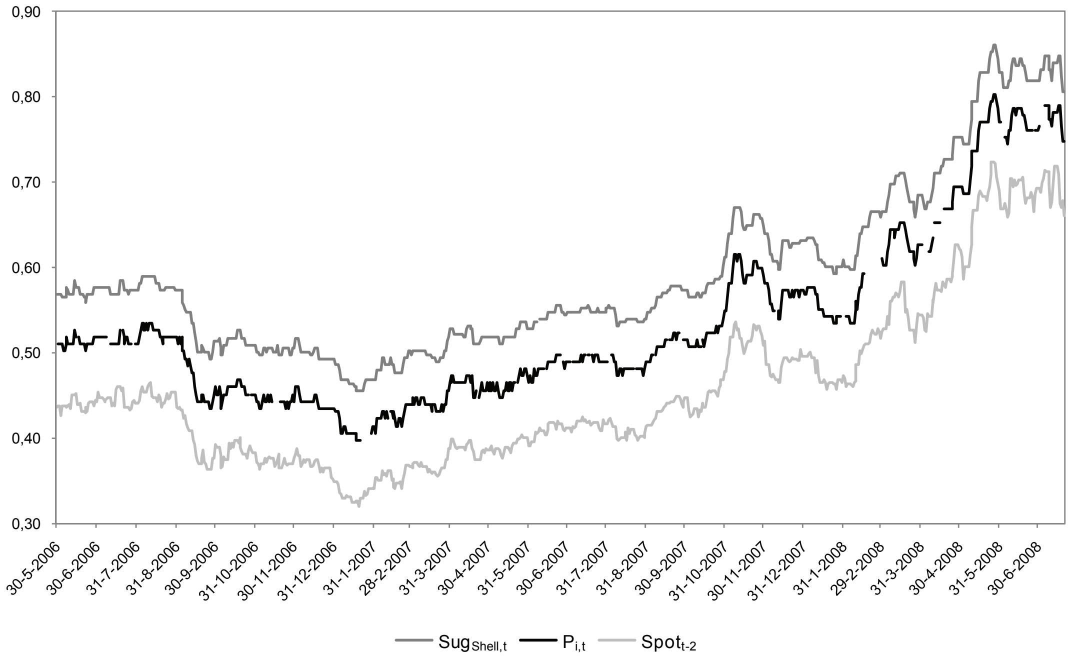
brands. We also show that it is unlikely that this coordinating effect is caused by the possibility that suggested price change in view of daily changes in demand.

It is important to stress that this coordinating effect does not imply that most retailers charge the suggested price. In fact, many retailers give a discount on the suggested price. What we show is that this discount is almost constant so that almost all retailers follow *changes in suggested prices*. As a consequence, the absolute differences between prices of stations are relatively constant over time.

It is less clear whether our results should be interpreted in the form of retailers coordinating retail prices or whether suggested prices affect costs of retailers and thereby influence retail prices indirectly. Due to a lack of data our attempt to discriminate between these two interpretations is only partly successful. Whichever of these interpretations is true, however, suggested prices certainly have a coordinating effect for the vertical chain of oil companies and retailers as a whole.

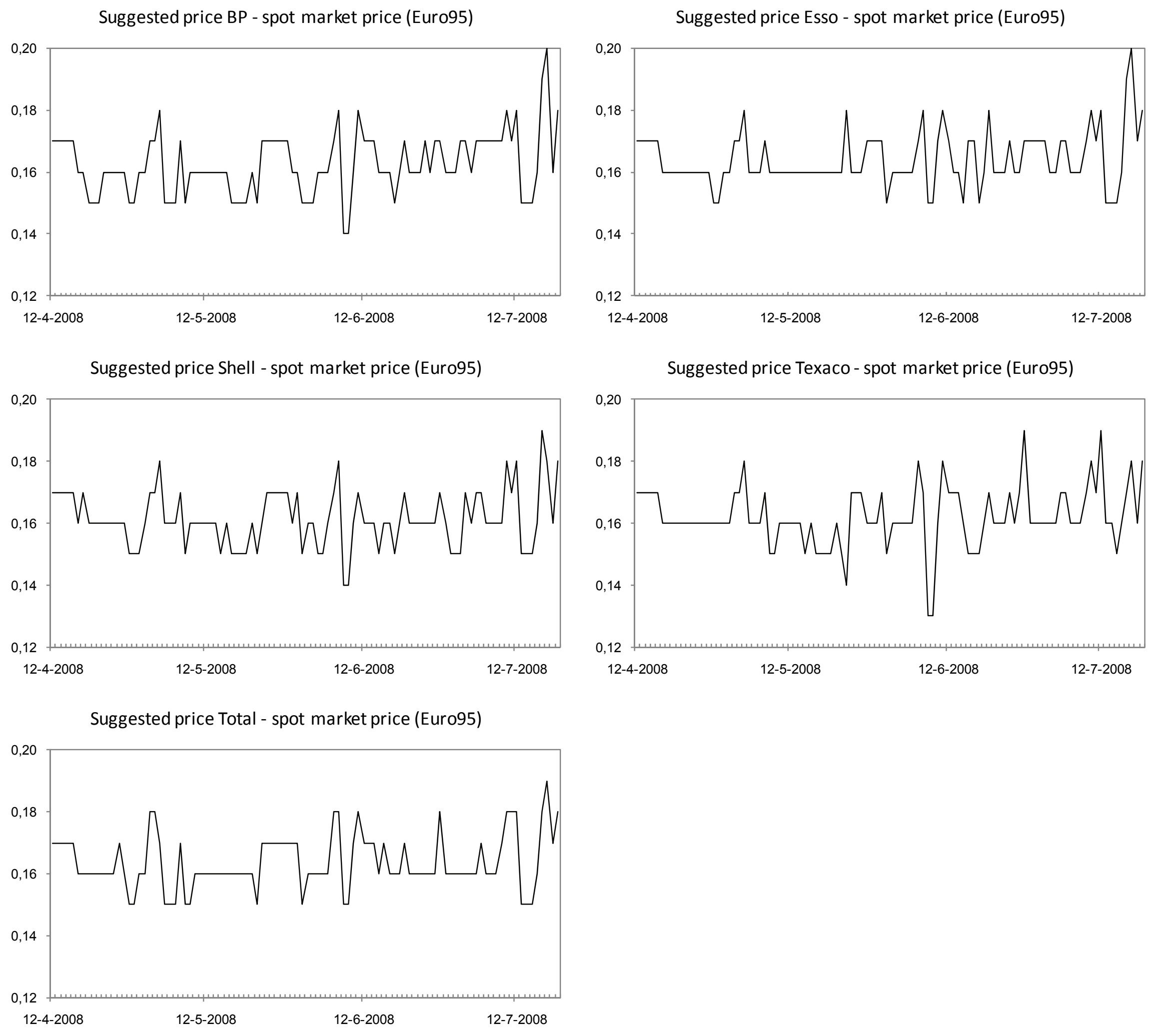
Appendix 2.A Extra figures and tables

Figure 2.A1 Shell suggested price, retail price of a representative Shell station, and spot market price for one liter Diesel



Notes: T=783, price in euro per liter (excluding excise duty and VAT).

Figure 2.A2 Suggested price - spot market price for all five brands (Euro95)



Notes: T=100, difference in euro per liter (excluding excise duty and VAT).

Table 2.A1 Estimation results Diesel

	Equation (2.1)	
	q=0, *r*=0	*q*=3, *r*=3
Sample	DO & Brand	DO & Brand
$\Delta P_{i,t-1}$		-0.37 (0.01)
$\Delta P_{i,t-2}$		-0.22 (0.01)
$\Delta P_{i,t-3}$		-0.11 (0.01)
$\Delta Spot_{t-2}$	0.89 (0.01)	0.93 (0.01)
$\Delta Spot_{t-3}$		0.34 (0.01)
$\Delta Spot_{t-4}$		0.20 (0.01)
$\Delta Spot_{t-5}$		0.11 (0.01)
$\Delta(\overline{Sug}_{-i,t} - Spot_{t-2})$	0.85 (0.01)	0.89 (0.01)
$\Delta(\overline{Sug}_{-i,t-1} - Spot_{t-3})$		0.33 (0.02)
$\Delta(\overline{Sug}_{-i,t-2} - Spot_{t-4})$		0.20 (0.02)
$\Delta(\overline{Sug}_{-i,t-3} - Spot_{t-5})$		0.11 (0.01)
$\Delta(Sug_{i,t} - \overline{Sug}_{-i,t})$	0.63 (0.02)	0.66 (0.02)
$\Delta(Sug_{i,t-1} - \overline{Sug}_{-i,t-1})$		0.24 (0.02)
$\Delta(Sug_{i,t-2} - \overline{Sug}_{-i,t-2})$		0.16 (0.01)
$\Delta(Sug_{i,t-3} - \overline{Sug}_{-i,t-3})$		0.07 (0.01)
$(P_{i,t-1} - Spot_{t-3})$	-0.03 (0.01)	-0.03 (0.01)
$(P_{i,t-1} - \overline{Sug}_{-i,t-1})$	-0.06 (0.01)	-0.02 (0.01)
$(P_{i,t-1} - Sug_{i,t-1})$	-0.20 (0.01)	-0.11 (0.01)
Observations	483,469	310,726
Stations	1,209	1,108

Appendix 2.B Most gasoline stations follow the suggested price on most days

Figure 2.2 suggests that the four selected gasoline stations follow the suggested price almost every day, a fact that is difficult to explain by the interpretation that suggested prices influence retail prices only through their impact on accounting cost. To do the analysis more rigorously, we first pool all our retail price data across time and stations.[35] Table 2.B1 shows how often a retail price changes, given that the relevant suggested price (the suggested price of the oil company with the brand of the gasoline station) changes. It shows that if the suggested price changes, the retail price also changes in 73% of all cases. Moreover, if the suggested price does not change, the retail price also does not change in 77% of all cases. We split the upper left cell of Table 2.B1 for the direction of the suggested price change. If the suggested price increases, then 97% of all changing retail prices increase as well. Furthermore, if a suggested price decreases, then 96% of all changing retail prices decrease.

Next we analyze the size of the differences. The first column of Table 2.B2 shows that in 72% of all observations, the size of the change in the retail price equals the change in the suggested price. If the suggested price changes, 57% of all changes in the retail price are equal to the change in the suggested price. The fourth column of Table 2.B2 shows that if both the suggested price and the retail price change, then in 78% of all cases the change in the retail price equals the change in the suggested price.

[35] Calculations in this appendix are based on Euro95 observations of dealer-owned stations with the brand of one of the five largest oil companies. We only report results for Euro95 since results for Diesel are similar.

Table 2.B1 Frequencies of retail price changes conditional on suggested price changes

	if $\Delta Sug_{i,t} \neq 0$	if $\Delta Sug_{i,t} = 0$
$\Delta P_{i,t} \neq 0$	73%	23%
$\Delta P_{i,t} = 0$	27%	77%
	100%	100%

Table 2.B2 Frequencies of a similar change in the retail price and suggested price

		if $\Delta Sug_{i,t} \neq 0$	if $\Delta Sug_{i,t} = 0$	if $\Delta Sug_{i,t} \neq 0$ and $\Delta P_{i,t} \neq 0$
$\Delta P_{i,t} = \Delta Sug_{i,t}$	72%	57%	77%	78%
$\Delta P_{i,t} \neq \Delta Sug_{i,t}$	28%	43%	23%	22%
	100%	100%	100%	100%

Chapter 3

Price Setting and Asymmetric Price Responses: Evidence for Heterogeneity of Gasoline Stations[*]

Asymmetric price responses occur when prices rise more rapidly after an increase in costs than they decline after a decrease in costs (see Peltzman (2000)). Many policy makers, consumers, and consumer organizations are suspicious that this pricing behavior is common in many markets, in particular in agricultural and gasoline retail markets.[1] This chapter studies price responses of gasoline stations and oil companies in the Netherlands and focuses on the price setting and characteristics of individual firms.

There already exists a substantial literature on asymmetric price responses. Frey and Manera (2007) provide a survey of the empirical literature. Some of these papers focus on gasoline retail markets. For example, Borenstein, Cameron, and Gilbert (1997) study the U.S. gasoline market and find that semimonthly aggregated retail prices respond asymmetrically to wholesale price changes. Studies that use weekly data of individual gasoline stations are Lewis (2005) (420 stations), Verlinda (2008) (approximately 90 stations), Balmaceda and Soruco (2008) (44 stations), and Hosken, McMillan, and Taylor (2008) (272 stations). The first three studies report evidence at the market level for asymmetric retail price responses to spot market price changes.[2] Deltas (2008) investigates

[*] This chapter is a version of the paper "Asymmetric Price Responses of Gasoline Stations: Evidence for Heterogeneity of Retailers", Tinbergen Institute Discussion Paper, November 2009, 106/1.

[1] See, for example, European Commission, "Food prices in Europe" (9 December 2008), De Consumentenbond, "Supers woekeren met groente en fruit" (De Consumentengids, November 2008, pp. 32-33), De Consumentenbond, "Pompprijs volgt wereldmarkt" (De Consumentengids, April 2009, pp. 10-11), and De Telegraaf, "Mythes over benzineprijs zorgen voor veel onrust" (19 September 2008).

[2] Noel (2009) uses twice-daily prices of 22 gasoline stations and finds asymmetric pricing at the market level. However, there also exist Edgeworth cycles in this market. He shows that these cycles have an impact on asymmetric pricing.

asymmetry via monthly U.S. state retail prices, Lewis and Noel (2009) use daily city retail prices, and Radchenko (2005) uses weekly national retail prices. These studies also find evidence of asymmetric price responses. For the Netherlands, Bettendorf, Van der Geest, and Varkevisser (2003) and Bettendorf, Van der Geest, and Kuper (2009) study the daily suggested price of one oil company and find some evidence of asymmetric price responses to changes in the spot market price.

Asymmetric price responses are not consistent with standard models of perfect competition or monopoly. Most theoretical studies mark tacit collusion and a low search intensity as possible causes for asymmetry.[3] To empirically distinguish between these two causes is difficult. Verlinda (2008) and Deltas (2008) conclude that market power can be an important factor for explaining asymmetry.[4] However, market power can explain asymmetry via both tacit collusion (see Verlinda (2008)) and a low search intensity (see Deltas (2008)). Radchenko (2005) explains asymmetry via volatility of the input price (see also Peltzman (2000)) and finds that tacit collusion is a likely explanation.

Almost all studies of asymmetric price adjustments use (i) price data that have a lower frequency than the frequency of price decisions or input cost changes (they use, for example, weekly data) or (ii) data that are aggregated over large geographic areas (for example, an average national retail price).[5] These data limitations possibly lead to biased results (see also Geweke (2004)). First, to investigate asymmetric price responses it is important to have price data with a *similar frequency* as the highest frequency at which

[3] See Johnson (2002), Lewis (2005), Cabral and Fishman (2008), Deltas (2008), Yang and Ye (2008), and Tappata (2009) for an explanation using search costs. See Rotemberg and Saloner (1986), Haltiwanger and Harington (1991), Borenstein and Shepard (1996), Borenstein, Cameron, and Gilbert (1997), Balke, Brown, and Yücel (1998), and Verlinda (2008) for an explanation using tacit collusion.

[4] Verlinda (2008) links characteristics of gasoline stations to the existence of asymmetric pricing. He shows that brand identity, proximity to rival gasoline stations, and local market features and demographics all have an impact. Deltas (2008) concludes that U.S. states with higher average margins have a higher degree of asymmetry. However, Balmaceda and Soruco (2008) find that a group of branded stations and a group of stations with a high margin have the same degree of asymmetry as respectively a group of unbranded stations and a group of stations with a low margin.

[5] One exception is Balmaceda and Soruco (2008), who use weekly retail and spot market price data from Chile. Because of institutional factors gasoline stations and the state-owned oil company adjust prices only once a week.

price decisions are taken or input costs change. Only in this case will the analysis include all (possible) price adjustments.[6] Second, it is important to have data on price decisions of *individual gasoline stations* since an individual gasoline station, and not the market as a whole, chooses to adjust prices asymmetrically or not. It may very well be that not all gasoline stations have the same pricing strategy, for example, because they do not operate under the same conditions (competition, ownership structure, location, etc.). Moreover, even if all gasoline stations respond asymmetrically, it is possible that they do not all respond similarly to cost changes (for example, the speed of adjustment differs). For these reasons aggregated price data may have a summation bias.

This chapter studies the daily pricing behavior of almost all gasoline stations and oil companies in the Netherlands over more than two years. Oil companies issue national suggested prices for gasoline, but retail prices are decided at the station level (see also Chapter 2). I disentangle three main questions: (i) To what degree do oil companies respond asymmetrically to changes in the spot market price? (ii) To what degree do gasoline stations respond asymmetrically to changes in the spot market price and are there important differences between stations? (iii) What kind of gasoline stations respond asymmetrically? The first two questions study whether there exists heterogeneity in the pricing behavior of firms and the third question studies this heterogeneity.

To answer these questions, I use a panel data set consisting of daily gasoline prices of about 3,600 gasoline stations and daily suggested prices of the five largest oil companies over the period 30 May 2006 – 20 July 2008. By using this daily data set I can prevent

[6] Several papers report biases due to this type of data limitation. Bachmeier and Griffin (2003) use weekly and daily spot market data and show that their conclusions depend on the frequency of the data used. Noel (2009) shows that there may exist, next to asymmetric pricing, other irregularities in a market that have an impact on asymmetric pricing, but that cannot be observed in a low frequency data set. For example, the Edgeworth cycles that he finds take approximately one week. Eckert and West (2004) have a daily data set for a region in Canada and conclude that a subset of weekly observations is not sufficient for answering their research questions and can even be misleading. Moreover, Bettendorf, Van der Geest, and Varkevisser (2003) have daily data on a suggested price and estimate a separate model for each day of the week. For some days they find asymmetric prices responses, for others not. These results show that data selection may influence conclusions regarding asymmetric price responses.

possible estimation biases, since oil companies and almost all gasoline stations choose their prices on a daily basis and input costs for gasoline (the spot market price) also change daily. Moreover, I have data on the characteristics of individual gasoline stations, so it is possible to look into the characteristics of stations that price asymmetrically.

I find that none of the oil companies adjust their suggested prices asymmetrically to changes in the spot market price. I also find that there are significant differences between stations. Many stations do not price asymmetrically, but 38% of the stations do. Directly after a cost shock, the extent of asymmetry is substantial for these stations. One day after a 1 cent increase in the spot market price, the price at stations that adjust prices asymmetrically rises on average by 0.346 cent. One day after a 1 cent decrease in the spot market price, the price at these stations decreases by 0.153 cent on average. So after one day there is on average an asymmetry of 0.193 cent. However, for most stations that adjust prices asymmetrically, the asymmetry only lasts a short period of time. For asymmetrically pricing stations it takes on average about 10 days before the retail price fully reflects the change in the spot market price. The asymmetric part of this transmission process for most stations is directly after the cost shock and lasts only 1 or 2 days.

It is not clear why some gasoline stations set prices asymmetrically and others do not. I look at 35 (sometimes overlapping) station-specific characteristics that I associate with tacit collusion and/or search intensity (such as price level, ownership structure, and the number of close competitors). I do not find a clear pattern in the characteristics of asymmetrically pricing stations. Although I cannot find a clear explanation for asymmetry, this study implies that if there is an explanation, it should be found at the individual level, since some stations do and others do not adjust prices asymmetrically.

The contribution of this study to the already large literature on asymmetric price adjustments is that it gives insight in the pricing behavior of *individual* firms on a *daily* basis. This study shows that asymmetry is not a feature of the market as a whole, but of individual firms. For that reason the extent of asymmetry at the individual level is higher than the extent at the market level. I measure how many retailers adjust prices asymmetrically and study the differences between retailers. Up until now, there is very little literature on asymmetric pricing by individual retailers compared to the literature on asymmetry at the market level. Moreover, few empirical papers study characteristics of asymmetrically pricing retailers. Finally, because of the detailed data set I can rule out a possible bias caused by aggregation over individuals and minimize a possible bias caused by aggregation over time. The conclusions that I draw in this chapter would not be possible without this detailed data set. For example, the asymmetric part of the transmission process for most stations lasts only one or two days and takes place directly after a cost shock. So with weekly data the asymmetric part of the transmission process would have been unobserved.

This chapter is organized as follows. Section 3.1 describes the gasoline retail market and the data set. Each of the next three sections considers one of the three research questions. Section 3.2 studies whether oil companies adjust their suggested prices asymmetrically. Section 3.3 studies whether gasoline stations adjust their retail prices asymmetrically. Section 3.4 explores the characteristics of asymmetrically pricing stations. Section 3.5 concludes.

3.1 A description of the gasoline retail market and the data set

3.1.1 The gasoline retail market[7]

There are around 4,300 gasoline stations in the Netherlands with the five largest oil companies (BP, Esso, Shell, Total, and Texaco) having a total market share of around 70% (measured as the total number of stations using the brand of these five companies divided

[7] Unless mentioned otherwise, the source of the data in this section is BOVAG (2006).

by the total number of stations). Roughly speaking there are three types of ownership models: some stations (including almost all the larger stations along the highways) are company-owned and company-operated (coco), other stations are company-owned and dealer-operated (codo), and the remaining stations are dealer-owned and dealer-operated (dodo). Coco stations are not free to set their own gasoline prices: these prices are set at the central company level. Dealers of codo stations rent the station from the oil company, participate in the company's sales and loyalty programs, but are free to set their own prices. Finally, dodo stations operate most independently from the larger oil companies, although even these stations have to buy the gasoline they sell from the oil company. Approximately 60% of the stations are dealer-owned. Rough estimates indicate that around 80% of the stations are dealer-operated.

There is a close relation between the input prices for gasoline and the prices on the international market. Although the large oil companies cover the complete production chain from extracting oil to selling gasoline, the Dutch gasoline sales divisions mainly buy their gasoline at the Amsterdam-Rotterdam-Antwerp (ARA) spot market which supplies large parts of western Europe. A price for this spot market is published once a day. Shell (the largest oil company) claims that even if the Dutch sales division buys gasoline from a production division, it uses this spot market price as internal price.[8]

The larger oil companies have suggested prices that they determine on a daily basis. Shell has published detailed descriptions on how it calculates the suggested price (see, e.g., Shell (2001) and the Shell website). Shell claims that every morning it takes the spot market price of the previous day (which is the most recent price available) and adds different taxes and margins (for transport, sales costs, etc.) to come up with a price it thinks gasoline stations should charge for their gasoline. If this price is different from the current price, a pricing committee meets to determine whether it changes the suggested price and by how much. If the committee decides to change the price, the oil company communicates the

[8] www.shell.nl

new price (which is valid from the next day onward) via fax and e-mail to all dealers in the evening. Dealers can then update their prices the next morning. If oil companies indeed follow this decision process, the delay between changes in the spot market price and prices at stations is exactly two days.

3.1.2 The data set

Retail gasoline prices are published daily on the website of Athlon Car Lease.[9] This company leases cars to other firms including a so-called “fuel card”. If the driver fills up his car with gasoline, he shows the card to the station and the retailer electronically sends the bill with price and quantity information to the lease company at the same time. As a result, Athlon Car Lease obtains gasoline price notations from 120,000 drivers, who fill up on average twice a week, from all over the Netherlands. Athlon Car Lease puts the data on gasoline prices on its website and I have downloaded the data daily over the period 30 May 2006 – 20 July 2008. As indicated in the previous subsection, there are approximately 4,300 gasoline stations in the Netherlands, of which the data set includes about 3,600. Stations that the data set does not include seem to be mostly smaller and nonactive stations randomly distributed over the country. The amount of stations I report throughout the chapter is not exactly equal to the number of physical stations. For some gasoline stations in the data set, the name changes during the sample period and I do not merge the series of these stations. Data are available for seven different kinds of gasoline: Euro95, Diesel, Super, Super Plus, Special Euro95, Special Diesel, and untaxed Diesel. I focus on Euro95. The whole data set contains approximately 6,000 unique station-gasoline type-price quotations per day.[10] For each station-gasoline type combination I have a maximum of one price quotation per day. Since less busy stations have a lower probability of being visited

[9] www.athloncarlease.nl

[10] Only a couple of observations in the data set are suspicious. There seem to be a few cases where a certain type of gasoline is reported as another kind of gasoline. I deleted these quotations.

by a driver of a car leased from Athlon Car Lease, the data set contains more quotations of busier stations. This does not have an impact on the analysis, however, as there is no indication that the pricing decisions of larger gasoline stations differ significantly from that of smaller ones (after correction for ownership structure). Finally, drivers do not have to pay for the gasoline (because the firm that employs the driver does). So these drivers do not avoid more expensive stations. Casual observation shows that they also do not avoid cheaper stations.

I matched individual stations in the data set to lists of station-specific characteristics, namely owner and brand of a station and whether a station is located along a highway.[11] I do not have data on the operator of a station, but I do know the ownership structure. As a consequence, I am able to filter out the stations where an oil company decides on the price. I also matched each station to data on the area in which the station is located (income per capita, population, number of cars, number of people older than 60, number of immigrants (all per 4 digit zip code), and unemployment (per municipality)).[12]

During the sample period I downloaded the suggested prices from the website of United Consumers. This website contains daily suggested prices of the five largest oil companies for eleven different types of gasoline (some types are brand specific).[13] The spot market notation I use is the daily Platt's Barges FOB Rotterdam High (series for Euro95: Premium Gasoline 10 PPM). Shell uses the same notation for calculating the suggested price (Shell (2001)).

[11] I obtained lists with the ownership structure and brand of a station from Catalist (a company collecting data on gasoline stations) and a list with highway stations from the Dutch Ministry of Finance. It may be that stations change their brand or ownership structure during the sample period. As I do not have information on this, I assume that stations do not change their brand and ownership structure.

[12] The source of these data is the website of Statistics Netherlands.

[13] The suggested price of Shell increases 125 times and decreases 122 times during the sample period. For other brands these numbers are similar.

The websites of the European Central Bank and the Dutch Ministry of Finance provided respectively the dollar-euro exchange rate and data on taxes. I converted all gasoline prices to prices per liter (*excluding taxes*) in euros.

3.2 Do oil companies respond asymmetrically?

In this section I study if oil companies adjust their suggested prices asymmetrically to changes in the gasoline spot market price. Augmented Dickey-Fuller unit root tests indicate that the spot market price and suggested prices of the five largest oil companies are integrated of order 1. Therefore I estimate asymmetric error correction models to take into account possible cointegration between the suggested price and the spot market price.[14] The long-run relationship between the spot market price and the suggested price for each oil company i is:

$$Sug_{i,t} = \alpha_i^* Spot_{t-2} + c_i^* + \tau_i^* Time_t + \lambda_i^* Mix_t + \varepsilon_{i,t}^* \tag{3.1}$$

where $Sug_{i,t}$ is the suggested price of oil company i for one liter of gasoline on day t, $Spot_{t-2}$ is the gasoline spot market price on day t-2, and c_i^* is a constant that reflects the average gross margin for the oil company and gasoline station. $Time_t$ is a time trend that captures a possible inflationary increase in the margin, Mix_t is a dummy variable which is 1 after January 1st 2007 (law requires oil companies to add biofuels from that date onward), and $\varepsilon_{i,t}^*$ is an error term. All prices are in euro per liter and exclude excise duty and VAT. I use the two-day lagged spot market price for gasoline, since this is the relevant input price for the suggested price (see Section 3.1).[15]

[14] These are the standard models in this literature, see, e.g., Bachmeier and Griffin (2003) and Frey and Manera (2007).

[15] The spot market price has the highest correlation with the suggested price if I use a two-day lag.

I choose a linear relationship instead of a log specification because the data show that the absolute difference between the suggested price and spot market price is stable and independent of the level of the spot market price (see also Borenstein, Cameron, and Gilbert (1997)). Taxes do not differ substantially over the estimation period and I do not consider their impact. I do not make a distinction between changes in the exchange rate and changes in the spot market price in dollars.

If the residuals of Equation (3.1) are stationary, a cointegrating relation exists. In that case I can superconsistently estimate the coefficients in Equation (3.1) and define a short-run relation between the variables. First, I specify for each oil company a symmetric relation between the suggested price and the spot market price:

$$\Delta Sug_{i,t} = \alpha_{i,1}\Delta Spot_{t-1} + \sum_{j=0}^{k}\alpha_{i,2+j}\Delta Spot_{t-2-j} + \sum_{j=1}^{l}\beta_{i,j}\Delta Sug_{i,t-j} + \gamma_i\varepsilon^{*}_{i,t-1} + \mu_{i,t} \tag{3.2}$$

where $\mu_{i,t}$ is an error term.[16] In this equation I include the one-day lagged change in the spot market price as well. The two-day lagged spot market price is the relevant price for the suggested price (see Section 3.1 and Equation (3.1)). This price is the most recent quotation available at the moment the pricing decision is made. However, at the moment that an oil company decides on its suggested price for day *t* (the morning/afternoon of *t*-1), it can take into account the movements of the spot market price it perceives on *t*-1 (or it can look at prices of related products (e.g., crude oil) for which real-time price data are available). I use the change in the one-day lagged spot market price as a proxy for the new information that became available since the most recent daily spot market price was published.

[16] Equation (3.1) and (3.2) can be rewritten into a standard ARDL(*k*+1,*l*+1) model.

Second, I specify an asymmetric relation between the suggested price of an oil company and the spot market price:[17]

$$\Delta Sug_{i,t} = \alpha_{i,1}^{+}\Delta Spot_{t-1}^{+} + \alpha_{i,1}^{-}\Delta Spot_{t-1}^{-} + \sum_{j=0}^{v}\alpha_{i,2+j}^{+}\Delta Spot_{t-2-j}^{+} + \sum_{j=0}^{w}\alpha_{i,2+j}^{-}\Delta Spot_{t-2-j}^{-}$$

$$+ \sum_{j=1}^{x}\beta_{i,j}^{+}\Delta Sug_{i,t-j}^{+} + \sum_{j=1}^{y}\beta_{i,j}^{-}\Delta Sug_{i,t-j}^{-} + \gamma_i^{+}\varepsilon_{i,t-1}^{*+} + \gamma_i^{-}\varepsilon_{i,t-1}^{*-} + \mu_{i,t} \qquad (3.3)$$

where for each variable z: $\Delta z^{+} = \max\{\Delta z, 0\}$ and $\Delta z^{-} = \min\{\Delta z, 0\}$. And where $\varepsilon_{i,t-1}^{*+} = \max\{\varepsilon_{i,t-1}^{*}, 0\}$ and $\varepsilon_{i,t-1}^{*-} = \min\{\varepsilon_{i,t-1}^{*}, 0\}$. A plus (minus) as superscript to a coefficient indicates that the coefficient belongs to an increasing (decreasing) variable. Besides price asymmetry via the impact of current and lagged changes in the spot market price and lagged changes in the suggested price, it is also possible that there is asymmetry in the speed of adjustment to the equilibrium suggested price. If $\left|\gamma_i^{-}\right| > \left|\gamma_i^{+}\right|$, then the suggested price returns more slowly to its equilibrium value if the suggested price exceeds its equilibrium value.

Inspection of the data shows that the five largest oil companies never change suggested prices on Sundays and rarely on Mondays. This is possibly the case because the suggested prices for these days should be decided on Saturdays and Sundays and these are not working days. Since I would like to explain suggested prices by the spot market price and not by working schedules, I exclude from my sample the days for which the suggested price should be decided during weekends and official national holidays (547 out of 783 days are left). So differenced variables reflect differences between days on which oil companies decide on the suggested price.

[17] A long-run asymmetric relation between the spot market price and suggested price cannot exist. If in the long run the pass-through of increases in the spot market price is stronger than the pass-through of decreases, this would imply that margins would increase infinitely over time.

I estimate a separate specification for each oil company. I use the Engle-Granger two-step estimation procedure and estimate all equations by OLS. To interpret the estimation results and test for asymmetric price responses, I calculate cumulative adjustment functions (see Borenstein, Cameron, and Gilbert (1997)). These functions measure the cumulative change in the suggested prices after a 1 cent increase and a 1 cent decrease in the spot market price. I compute the cumulative change in the suggested prices up to 25 days after the shocks. The difference between the cumulative change in the suggested price after a 1 cent increase and a 1 cent decrease in the spot market price reflects the degree of asymmetry at a certain point in time.

First I estimate Equation (3.1) for each oil company. Then I take the residuals and estimate Equation (3.3) for each oil company. I choose the lag lengths (v, w, x, and y) by using the Schwarz information criterion and this procedure results in lag lengths of zero for all variables and brands.[18] I use White heteroskedasticity-consistent standard errors. The residual-based test for cointegration rejects the null of no cointegration for all five oil companies. Table 3.A1 in Appendix 3.A shows the estimation results. The estimated coefficient for the long-run impact of the spot market price is close to 1 for all five brands. Thus, in the long run there is a full pass-through of changes in the spot market price into the suggested price.

Figure 3.1 shows the cumulative adjustment functions of the suggested prices after a 1 cent positive and a 1 cent negative change in the spot market price. The figure also reports the difference between the cumulative adjustments and its 95% confidence interval.[19] I first discuss the cumulative adjustment of Brand A (upper left corner of the figure). It shows that the difference is positive in the first few days after the change in the spot market price, but the difference is never significantly different from 0 (0 is always in the 95% percent confidence interval). For example, two days after an increase, the pass-through in the

[18] Only for Brand B the Schwarz information criterion prefers w=1, but differences are minor and for comparison with the other brands I report results for w=0.

[19] I use the delta method to derive the standard errors.

suggested price is 0.581 cent. However, two days after a decrease, the pass-through is only 0.485 cent. No difference remains after about four days. After approximately seven days the oil company has fully absorbed the shock in its suggested price. The cumulative adjustment functions for the other oil companies are similar. For all five oil companies there is some asymmetry, but this is never statistically significant.

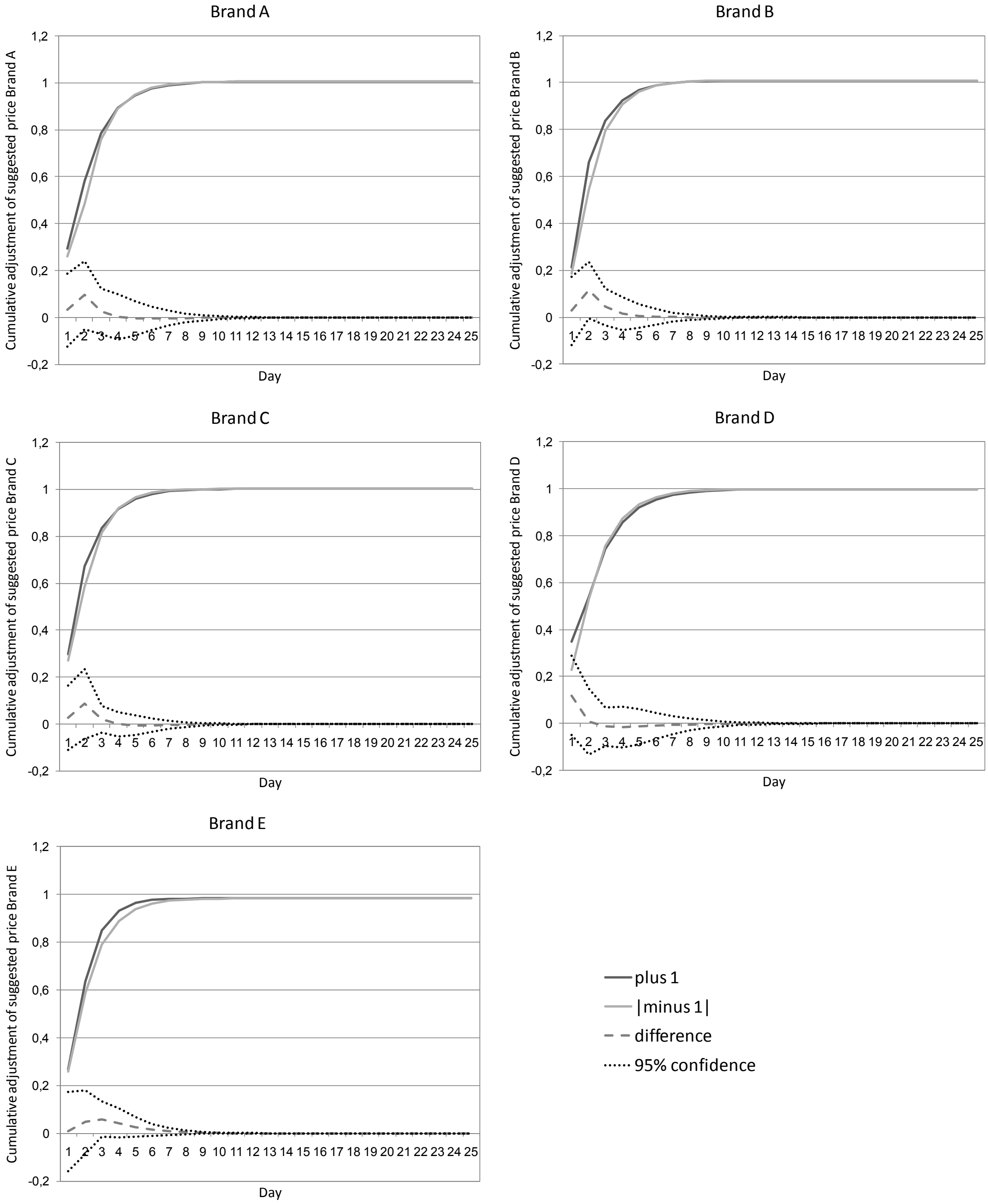
3.3 Do gasoline stations respond asymmetrically?

In this section I take up the question whether gasoline stations adjust their retail prices asymmetrically to changes in the spot market price. I define $P_{i,t}$ as the retail price of station i for one liter of gasoline on day t (in euro per liter, excluding excise duty and VAT). Since I already modeled the relation between the spot market price and suggested price in Section 3.2, I obtain the appropriate equations for the relation between the spot market price and retail price by taking Equation (3.1), (3.2), and (3.3) and simply replace $Sug_{i,t}$ by $P_{i,t}$ in these equations (I refer to these equations as respectively (3.1’), (3.2’), and (3.3’)).[20] In Equation (3.1’), (3.2’), and (3.3’), the subscript i refers to gasoline station i.

In contrast to oil companies, gasoline stations are open on weekends and during holidays and thus have the opportunity to change their price on these days. For that reason I include all days in the sample. I estimate the relationship when all gasoline stations are pooled (to measure asymmetry at the market level) and also for each individual gasoline station (to measure asymmetry at the firm level). To interpret the estimation results I calculate cumulative adjustment functions to measure the cumulative change in the retail prices up to 25 days after a 1 cent increase and a 1 cent decrease in the spot market price.

[20] The one-day lagged spot market price is not a proxy for new information in this specification since gasoline stations know this price at the moment that they decide on their retail price. The change in the current spot market price has no explanatory power for the change in the retail price. I take the two-day lagged spot market price as the long-run equilibrium price. The retail price has the highest correlation with the spot market price if I use a two-day lag. Moreover, the two-day lagged spot market price is the basis for the suggested price (see Section 3.1). Chapter 2 shows that many retailers use the suggested price for setting their price.

Figure 3.1 Cumulative adjustments of the suggested prices (after spot market price change)



3.3.1 All stations pooled

First, I estimate the pooled equation. This implies that $\psi_i = \psi$ for each coefficient and the error term in Equations (3.1'), (3.2'), and (3.3'). I use Driscoll-Kraay standard errors that are robust to heteroskedasticity, serial correlation, and cross-sectional correlation (see Driscoll and Kraay (1998) and Hoechle (2007)). Augmented Dickey-Fuller Fisher panel unit root tests (Maddala and Wu (1999), Choi (2001)) indicate that retail prices are, like the spot market price, integrated of order 1. The panel cointegration test of Kao (1999) reveals homogeneous cointegration between retail prices and the spot market price. The lower part of Table 3.A2 in Appendix 3.A shows the parameter estimates of Equation (3.1'). The estimated coefficient for the long-run impact of the spot market price is 0.993. The upper part of Table 3.A2 shows the estimation results of Equation (3.2') and Equation (3.3'). I present three different specifications. The results of these specifications are similar. To further interpret the results, I look at the cumulative adjustment function.

Figure 3.2 shows the cumulative adjustment function for v=w=x=y=1. There is significant asymmetry at the market level. However, the extent of asymmetry is moderate and the asymmetry lasts for a short time. The difference in the cumulative change in the retail price after a 1 cent increase and a 1 cent decrease in the spot market price is significantly different from 0 on the first day after the shock (the absolute difference is 0.120 cent). On day 2 there is a still a difference (0.062 cent), but this is not significantly different from 0. After these two days the difference is negligible. After 16 days, retail prices have adsorbed more than 97.5% of both the positive and negative shock. The sum of the difference between the positive and negative cumulative adjustment equals 0.199 cent after 25 days. So if a consumer buys 1 liter per day for 25 consecutive days after the shock, the consumer pays in total 0.199 cent more after a 1 cent increase in the spot market price than what the consumer would save after a 1 cent decrease. On an average day gasoline stations sell in total 14,3 million liters of Euro95 (data for 2004, BOVAG (2006)). So this back-of-the-envelope calculation shows that all consumers together pay 28,423 euros more after a 1 cent increase in the spot market price than they save after an equal decrease. In the next paragraphs I study asymmetry at the firm level.

3.3.2 Individual stations

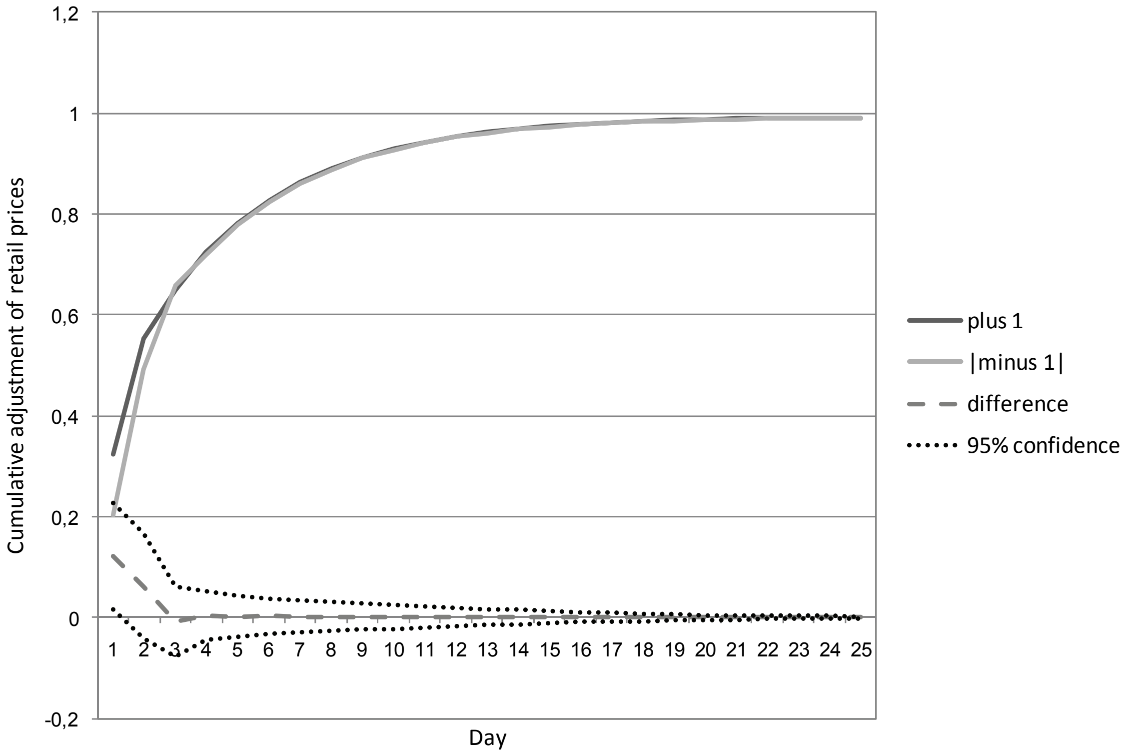
I estimate Equation (3.1') and (3.3') for 2,365 gasoline stations.[21] I choose a maximum value for v, w, x, and y of 3 and select the lag length via the Schwarz information criterion.[22] Figure 3.A1 and 3.A2 (Appendix 3.A) show distributions of the parameter estimates. The mean of the estimated long-run impact of the spot market price on the retail price is 0.988. Based on these and the other estimated coefficients, I calculate a cumulative adjustment function for each station.

First, I calculate the percentage of gasoline stations that adjust prices asymmetrically. For each gasoline station I calculate the number of days for which the difference between the cumulative price change after a positive shock and after a negative shock is positive and significantly different from 0 at the 5% significance level. When this number of days is one or more, I define a station as responding asymmetrically. Most gasoline stations do not price asymmetrically. However, a substantial part of the gasoline stations do. Table 3.1

[21] The sample contains 4,004 stations. For 2,549 stations there is enough data to estimate both Equation (3.1') and (3.3'). I exclude 7 stations because the residual-based test for cointegration could not reject the null of no cointegration in Equation (3.1') (all price series of the estimated stations are integrated of order 1). Furthermore, I exclude 49 stations because the estimated γ_i^+ or γ_i^- in Equation (3.3') is not between -2 and 0 (indicating that for these stations the retail price does not return to its equilibrium value) and 128 stations for which 20 or fewer observations that differ from 0 are available for estimating one of the parameters in Equation (3.3') (more restrictive conditions do not change results much). There are 2,365 stations left. I correct the standard errors of 1,148 stations for heteroskedasticity and of 910 stations for heteroskedasticity and serial correlation.

[22] If I use a higher maximum lag length I can estimate the equation for fewer stations and in practice only a limited number of stations use more than 1 lag.

Figure 3.2 Cumulative adjustment of retail prices (after spot market price change, pooled estimation)



shows that 38% of the gasoline stations respond asymmetrically.[23] The table also shows the *total length* of the asymmetric part of the transmission process. This total length differs between stations, although for most stations that adjust prices asymmetrically the asymmetry exists for only 1 or 2 days. There is hardly any station for which a positive shock leads to a significantly larger cumulative price adjustment than a negative shock for 5 days or more.

[23] Although the intuitive interpretation of this percentage is straightforward, the exact interpretation is not obvious because it is not clear what this percentage would be if there were no asymmetric pricing. If I test once for each gasoline station the null hypothesis of symmetry at a 5% significance level, then the test falsely rejects symmetry for 5% of the stations. As a consequence, I expect that if none of the gasoline stations adjust prices asymmetrically, the tests indicate that 5% of the stations do price asymmetrically. In my case this analysis is more complicated because I define a station as pricing asymmetrically if for at least 1 out of 25 days the difference is positive and different from 0 at the 5% significance level. I do not correct the reported percentages for this effect.

Table 3.1 Percentage of stations that adjust prices asymmetrically and the total length of the asymmetric part of the transmission process

	plus>minus		minus>plus	
	number of stations	% of stations	number of stations	% of stations
Total	2,365		2,365	
0 days	1,468	62%	2,200	93%
1 day or more	897	38%	165	7%
1 day	686	29%	72	3%
2 days	135	6%	24	1%
3 days	20	1%	16	1%
4 days	19	1%	15	1%
5 days	9	0%	9	0%
6 days or more	28	2%	29	1%

Second, I study on *which days* the transmission processes are asymmetric. Does asymmetry arise directly after the shock or only after a couple of days? For each day I calculate the number of gasoline stations for which the difference between the cumulative price change after a positive shock and a negative shock is positive and significantly different from 0. Figure 3.3 shows the results. Most asymmetry takes place on the first day after the shock. On the first day, for 637 out of 2,365 gasoline stations (27%) the difference in the cumulative price change after a positive and negative shock is positive and significantly different from 0. On day 2 the difference is positive and significant for 169 stations. After day 2, this number decreases further and becomes small.

Third, I calculate the extent of the asymmetry. For each day I compute for the 38% of the gasoline stations that respond asymmetrically the average difference between the cumulative price change after the positive and negative 1 cent shock. Figure 3.4 shows the result. The asymmetry is on average 0.193 cent on the first day, but declines over time. One day after a 1 cent shock, the price of asymmetrically pricing stations increases on average by 0.346 cent after a positive shock and decreases on average by 0.153 cent after a

Figure 3.3 The number of stations that respond asymmetrically per day

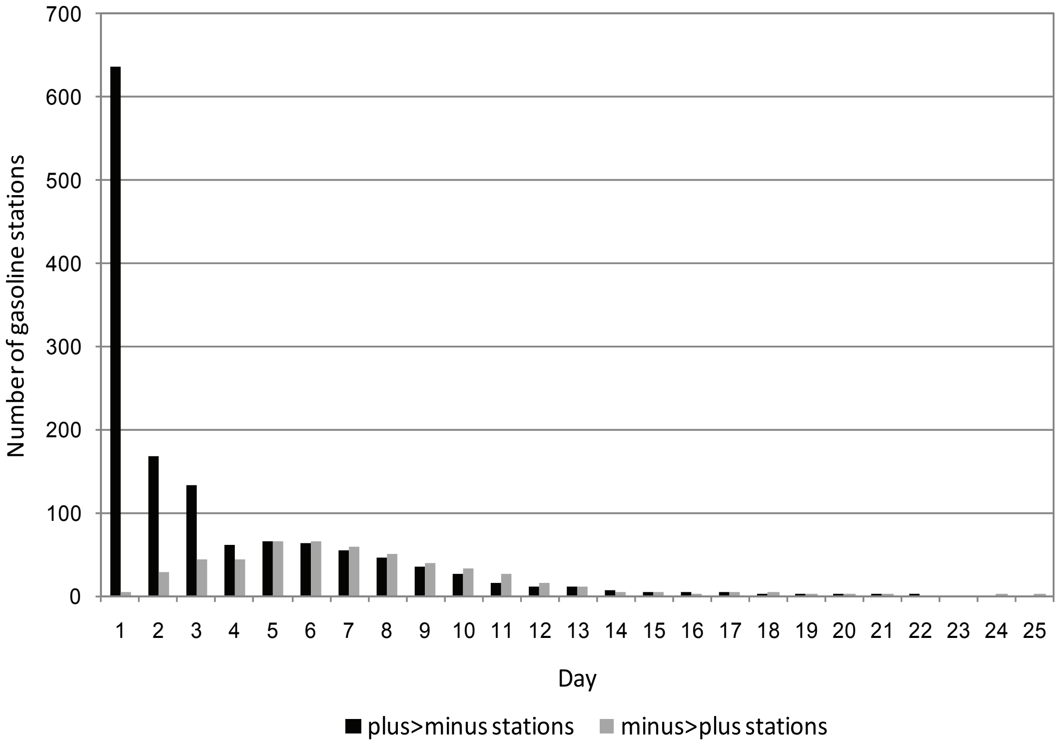
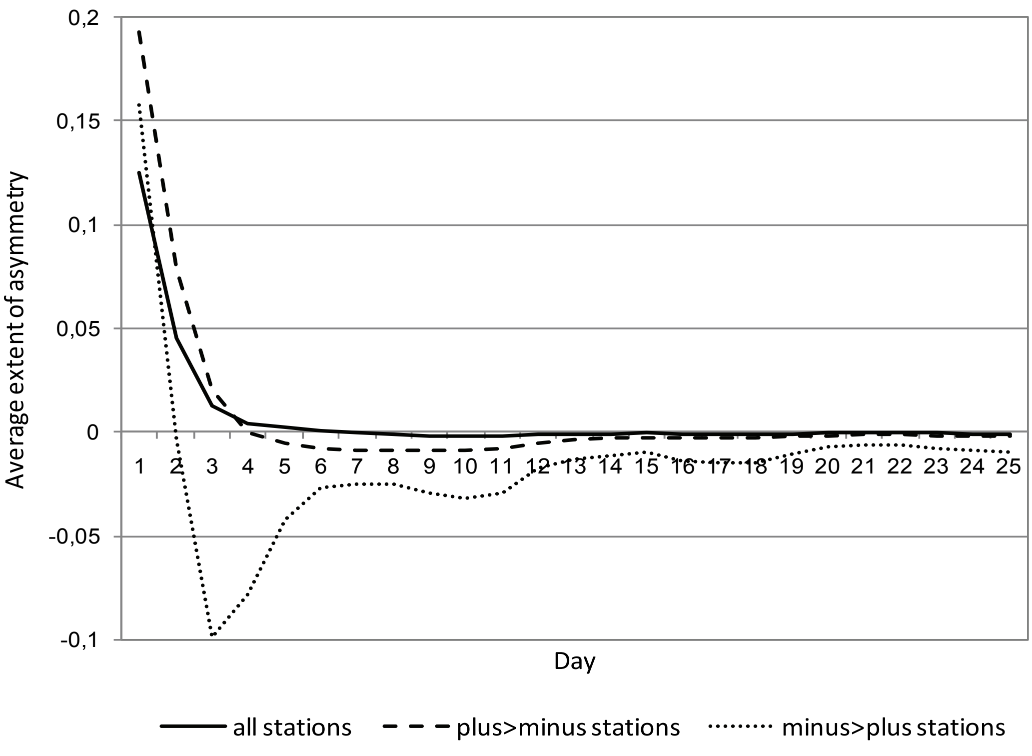


Figure 3.4 Average extent of asymmetry (difference between the cumulative adjustments)



negative shock. This means that a consumer pays at stations that adjust prices asymmetrically on average 0.193 cent more if it is a positive shock than what the consumer saves if it is a negative shock. On day 3 the difference is close to 0. To place these numbers in perspective, Figure 3.4 also contains the average difference between the cumulative price change after a positive and negative shock for all 2,365 estimated gasoline stations (so including the stations that adjust prices asymmetrically). It shows the importance of measuring the extent of asymmetry at the firm level. The average extent of asymmetry in the first days differs substantially between all stations and the stations that adjust prices asymmetrically. On day 1 the mean of the difference over all stations is positive and equals 0.125 cent (this is close to the value from the pooled estimation). Thus, on day 1 the estimated extent of the asymmetry is on average 0.068 cent (54%) larger when I only take into account stations that adjust prices asymmetrically.

Fourth, to measure the length of the full transmission process, I calculate the number of days that it takes before the cumulative change in the retail price almost equals the long-run pass-through α_i^* (I calculate the number of days that the price is outside the interval $\{0.975\,\alpha_i^*,\ 1.025\,\alpha_i^*\}$). Figure 3.5a shows for all gasoline stations the length of the transmission process after a positive shock. For asymmetrically pricing stations it takes on average 9.8 days and for other stations 8.8 days. I also calculate the length of the transmission process after a negative shock. Figure 3.5b depicts for each gasoline station the difference between the length of the transmission process after a positive and negative shock. For a majority of stations this difference is around zero (mean difference is 0.3 days). This indicates that the full pass-through of a positive and negative shock takes the same amount of time. However, for asymmetrically pricing stations the full transmission process is on average shorter after a negative shock than after a positive shock (1.1 days). This difference arises because asymmetrically pricing stations take more time in the case

Figure 3.5a Length of the transmission process after a positive shock

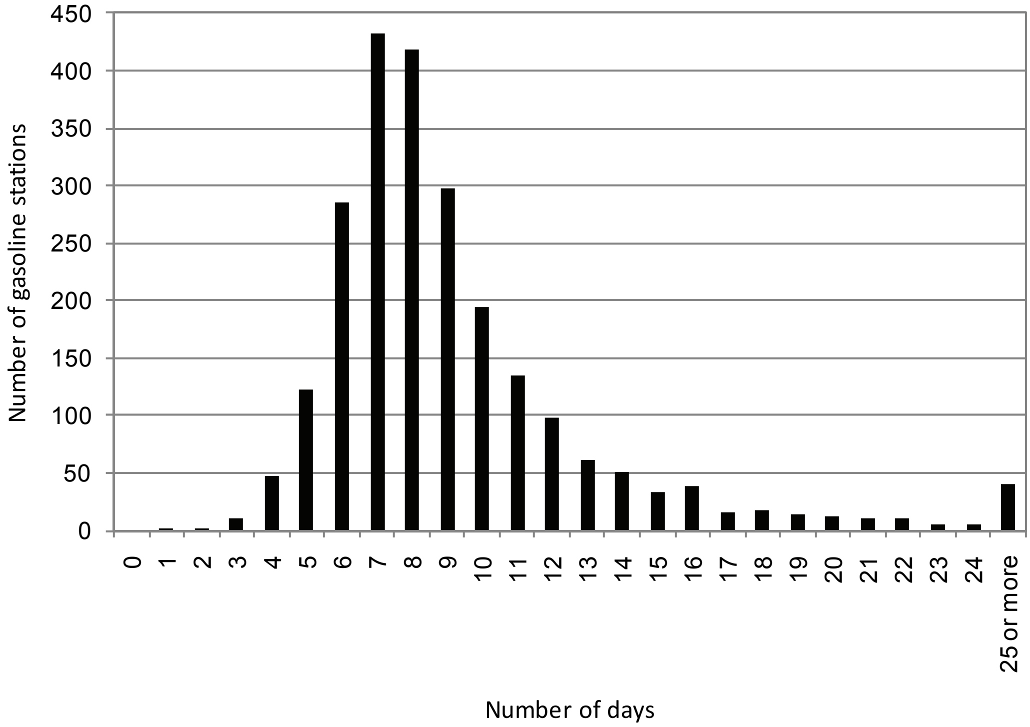
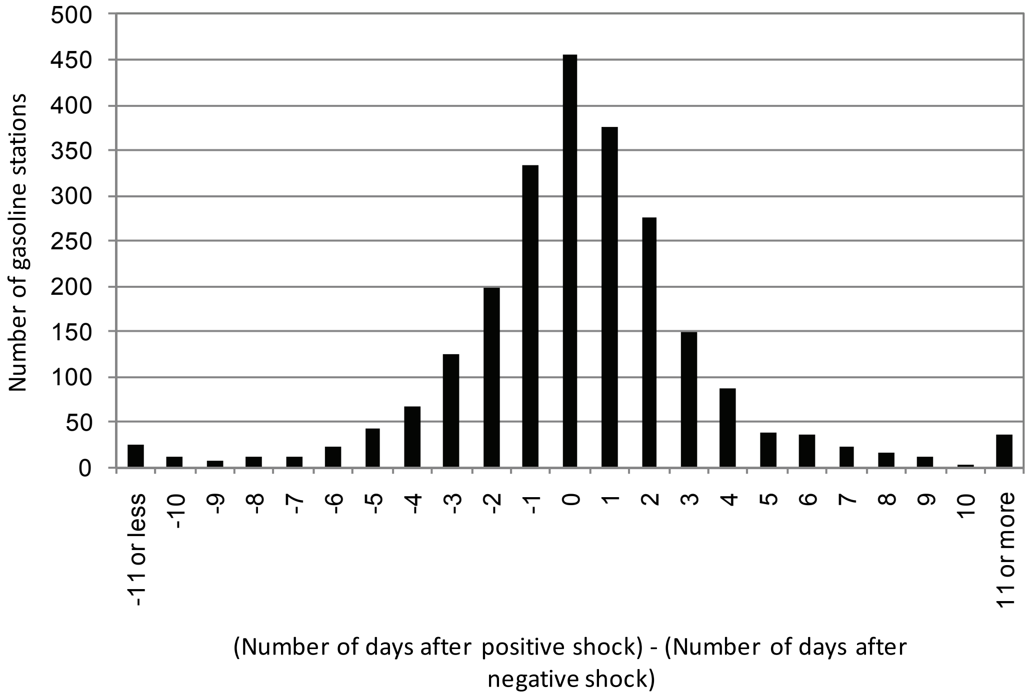


Figure 3.5b Difference in length of the transmission process after a positive and negative shock



of a positive shock and a bit less time in the case of a negative shock compared to other stations.[24]

Up until now, I looked into the possibility that the pass-through of *increases* in the spot market price is faster than the pass-through of decreases. However, another possibility is that retail prices respond faster to *decreases* in the spot market price. The data show that gasoline stations do not often practice this type of pricing. I first calculate the percentage of gasoline stations that change their price faster after decreases than after increases. For each gasoline station, I compute the number of days on which the difference between the cumulative price change after a positive shock and after a negative shock is negative and significantly different from 0 at the 5% significance level. The fourth column of Table 3.1 shows that for 7% of the stations this occurs on at least one day.[25] For most of these stations this effect takes just one day in total. Figure 3.3 shows for how many gasoline stations the difference is significantly negative on each day. This number is the highest on day 5 (67 stations) and declines afterward. Figure 3.4 shows the extent of the effect for the 7% of gasoline stations. The average difference is positive on day 1, negative on day 2 (0.079 cent) and subsequently moves in the direction of 0.

As a robustness check, I also estimate Equation (3.3') with $\gamma_i^+ = \gamma_i^-$ and different maximum values for v, w, x, and y (this enlarges the number of observations per station). Table 3.2 reports the results. The percentage of gasoline stations that adjust their prices asymmetrically is between 30% and 42%, depending on the exact specification. The percentage of gasoline stations that respond faster to decreases than to increases in the spot market price varies between 1% and 8%.

[24] The individual estimations show on average a shorter estimated length of the transmission process than the pooled estimation. This possibly indicates a summation bias. The maximum length of the transmission process after a positive shock and after a negative shock is according to the pooled estimation 15 days. According to the individual estimations, this number is on average 10.1 days.

[25] There are 104 stations for which the difference between the cumulative price change after a positive and a negative shock is both significantly positive and significantly negative at least once.

Table 3.2 Alternative specifications for Equation (3.3')

	% of stations	
	plus>minus	minus>plus
max $v=w=x=y=3$	38%	7%
max $v=w=x=y=1$	38%	7%
max $v=w=x=y=0$	36%	5%
max $v=w=3$, $x=y=0$	42%	8%
max $v=w=3$, $x=y=0$; $\gamma_i^+ = \gamma_i^-$	38%	5%
max $v=w=x=y=0$; $\gamma_i^+ = \gamma_i^-$	30%	1%

Note: For all specifications I use the same 2,350 stations.

In Appendix 3.B I study whether gasoline stations respond asymmetrically to the suggested price that is announced by their oil company. Again the results indicate that there exists heterogeneity of stations. I find that 22% of the gasoline stations adjust their retail prices asymmetrically to changes in the suggested price. The pass-through of shocks in the suggested price is faster than of shocks in the spot market price, although the extent of the asymmetry is similar. One day after a 1 cent increase in the suggested price, the price of stations that adjust prices asymmetrically rises on average by 0.903 cent. One day after a 1 cent decrease in the suggested price, the price at these stations declines on average by 0.698 cent. As a result, for stations that adjust prices asymmetrically there is an average asymmetry of 0.205 cent on day 1. The difference with the estimated asymmetry at the market level is large, indicating the importance of the estimations per station. On day 1 the estimated asymmetry at the market level is only 0.043 cent. For asymmetrically pricing stations the transmission process after a positive shock takes on average 6.1 days. The asymmetric part of this transmission process for most stations is just one day and it takes place on the first days after the shock.

3.4 What kind of gasoline stations respond asymmetrically?

The previous section shows that there exists heterogeneity in the pricing behavior of gasoline stations: some stations adjust prices asymmetrically, while others do not. This shows that any explanation for price asymmetry has to be found at the firm level. Pure market level explanations of asymmetric price adjustments (for example, the nature of the production and distribution process or the volatility of the spot market price) would imply that all gasoline stations adjust prices asymmetrically.

This leads to the following questions: is there a systematic pattern in the type of stations that do price asymmetrically? Are there specific features that explain why stations price asymmetrically? Or is asymmetric pricing a more random phenomenon? Theoretical studies often explain asymmetric price adjustments by tacit collusion between retailers or a low search intensity of consumers. However, there exists no overarching theory that I can use to empirically test one theory against the other. For that reason, I do not try to answer *why* stations adjust prices asymmetrically, but I look at *which* stations adjust prices asymmetrically. I look for station-specific characteristics that are broad proxies for tacit collusion and/or a low search intensity. This "fishing expedition" may give input for further theoretical discussion on asymmetric pricing (Peltzman (2000) has a similar strategy). I find that characteristics of asymmetrically pricing stations and other stations do not differ much. Therefore, asymmetric pricing seems to be a random phenomenon in the population of gasoline stations. I first briefly discuss the two main theoretical explanations, then the methodology that I use, and finally I present the results.

3.4.1 Theory

Tacit collusion

Tacit collusion can explain asymmetric pricing as follows (see also the interpretation of Verlinda (2008) of Rotemberg and Saloner (1986), Haltiwanger and Harington (1991), and Borenstein and Shepard (1996)). If wholesale costs rise, the difference between the monopoly price and wholesale costs declines. This makes short-term collusive profits lower, therefore collusion is less attractive and markups are lower. On the other hand, if wholesale costs go down, the difference between the monopoly price and wholesale costs goes up, short-term collusive profits are higher, collusion is more attractive and as a result markups are higher. So when wholesale costs go up, firms compete. When wholesale costs go down, firms tacitly collude and keep prices high. In practice, the change in wholesale costs is about the same for all gasoline stations. However, because the market characteristics that make tacit collusion easier to sustain may differ between stations and areas, it is possible that tacit collusion, and thereby asymmetric pricing, is only present in some areas.[26]

This form of tacit collusion is very subtle as a short-term strategy for gasoline retailing, since firms would switch frequently between collusion and competition because wholesale costs change on a daily basis. Balke, Brown, and Yücel (1998) offer an alternative explanation in which firms do not frequently switch between tacit collusion and competition. Suppose that stations are tacitly colluding and that stations are uncertain about the wholesale costs of other stations. Moreover, this tacit collusion is so profitable that stations do not want to risk that the cooperation comes to an end. If the wholesale costs for a station rise, the station immediately increases its price to signal that it still participates

[26] Borenstein, Cameron, and Gilbert (1997) have a different, but similar, explanation. Suppose stations are not colluding and ask the equilibrium price. If wholesale costs rise, the equilibrium price rises and stations increase their retail price as well. If wholesale costs decrease, all stations may earn higher profits if none of the stations immediately lower their price. In that case stations coordinate their prices with the previous retail price as focal point. Over time, prices return to the new lower equilibrium price because of random changes in demand and the risk that this occurs due to undercutting competitors.

in the tacit agreement and that it does not try to cheat by lowering its margin. On the other hand, if the wholesale costs fall, the station is reluctant to lower its price because it might give the impression that the station is breaking the tacit agreement. As a result, stations respond asymmetrically to changes in the wholesale costs.

The following hypothesis tests if tacit collusion explains asymmetry. If a station can cooperate more easily with other stations and/or tacit collusion is more profitable, then there is a higher probability that it adjusts prices asymmetrically. For example, stations with the same brand can cooperate more easily and therefore I expect that an asymmetrically pricing station is more often surrounded by stations that have the same brand.

Low search intensity

A low search intensity can also cause asymmetric price adjustments (see Deltas (2008) and also Johnson (2002), Lewis (2005), Cabral and Fishman (2008), Yang and Ye (2008), and Tappata (2009)). Suppose consumers know the price for which they bought gasoline the previous time, but they do not know wholesale costs. If wholesale costs rise and a consumer comes to a gasoline station and sees a high retail price, the consumer does not know that the price has gone up because wholesale costs have gone up. So the consumer perceives this as a relatively high price and starts searching. As a result, there is strong competition and a low margin for the retailer. On the other hand, if wholesale costs decline, the consumer does not know this. A relatively high retail price still seems reasonable. The consumer does not search and this gives the retailer an opportunity to get a relatively high margin. In other words, the pass-through of wholesale cost changes is high when there is fierce competition because of high search intensity and low when there is less competition because of a low search intensity. Therefore asymmetry increases when search intensity decreases.[27] The degree to which consumers search depends on the costs and benefits that are specific to areas, stations, and individuals. For that reason it is possible that asymmetry is only present in some regions or at some stations.

The following hypothesis tests if a low search intensity explains asymmetric pricing. If a station is subject to a low profitability of search (high search costs or low search revenues) and/or is located in a region with a low number of searchers, then there is a higher probability that it adjusts prices asymmetrically. For example, income per capita is a proxy for the opportunity costs of searching, therefore I expect that asymmetrically pricing stations are more often located in areas with a high income per capita.

3.4.2 Method

It is difficult to empirically test the two aforementioned hypothesis against each other. Often it is possible to link an empirical observation to asymmetric pricing via both theoretical explanations. For example, Verlinda (2008) links market power to asymmetric pricing via tacit collusion and Deltas (2008) via a low search intensity. Another example is the number of competitors nearby a station. On the one hand, fewer competitors make it easier to tacitly collude and increases the probability that a station prices asymmetrically. On the other hand, fewer competitors increase consumers' search costs, so a low search intensity can also be the cause of the higher probability. Therefore, I link characteristics of stations to asymmetric pricing, but I do not try to provide a comprehensive answer on the process that leads to the empirical relation.

I divide all tested gasoline stations into two groups: one group with stations that adjust prices asymmetrically and one group with all other stations. I study whether stations in

[27] Janssen, Pichler, and Weidenholzer (2009) consider a sequential search model with incompletely informed consumers and study a specific gasoline retail market. Among other things, they find that prior beliefs of consumers about costs are important for explaining price distributions.

these two groups have similar characteristics. For both groups I calculate for each characteristic the average value of this characteristic over all stations in the group or the share of stations in the group with this characteristic. Afterward, I test for equality of the averages or shares via a t-test.

For each gasoline station I use 35 (sometimes overlapping) characteristics. Besides characteristics of individual stations, I also look at characteristics of the area in which a station is located. I take the 3 digit zip code area in which a station is located as a proxy for its direct market and the 2 digit zip code area as a proxy for its broader market. The Netherlands consists of 90 areas at the 2 digit zip code level (average size 375 km², average number of stations 44) and 829 areas at the 3 digit zip code level (average size 41 km², average number of stations 5).[28] Smaller areas do not provide more information.

Roughly, I include 5 kinds of station-specific characteristics: brand indicators (e.g., the specific brand and the ownership structure), location indicators (e.g., location along the highway, location near the border, and population size of the 3 digit zip code area in which the station is located), competitor indicators (e.g., the number of stations in the area in which a station is located), price indicators (e.g., the margin of the station), and search intensity indicators (e.g., the percentage of people aged 60 or older in the 3 digit zip code area where the station is located). The characteristics are broad proxies (or conditions) for the existence of tacit collusion and/or a low search intensity. Often the characteristics have a relation with both hypotheses.

3.4.3 Results

Table 3.3 shows the results of the calculations. The interpretation of the first line of the table is as follows: the first and second column show that 53% of all stations that adjust

[28] Some 3 digit zip code areas do not contain many stations. However, for all nonreported 2 digit zip code characteristics, the 3 digit equivalents provide similar results.

prices asymmetrically are company-owned while, of all other stations, 55% are company-owned. The third column shows the p-value of the t-statistic (null hypothesis of the t-test: the two percentages are equal). There is no significant difference between the two groups at all usual significance levels, so company ownership does not have a higher incidence in one of the two groups.

None of the characteristics show a substantial difference between the group of asymmetrically pricing stations and the group of all other stations. Of the 35 characteristics in the table, only 4 are significantly different at the 1% significance level. However, the economic impact of these 4 differences is small. I will first discuss the statistically significant results and then a few others.

First, I discuss whether asymmetrically pricing stations are closely located to each other. I look at three levels of geographic concentration: the 3 digit zip code level, the 2 digit zip code level, and the national level. I calculate the percentage of other stations that price asymmetrically in the zip code area of a station. Table 3.3 shows that this percentage is on average significantly higher for stations that adjust prices asymmetrically themselves. So there is a geographic concentration of stations that price asymmetrically at both the 2 and 3 digit zip code level. Although statistically significant, this effect is very small. To illustrate, stations that *do not* set prices asymmetrically are located in 3 digit zip code areas where on average 37% of the other stations set prices asymmetrically, while stations that *do* set prices asymmetrically are located in areas where on average 40% of the other stations price asymmetrically. To study clustering at the national level, Figure 3.6 shows the percentage of stations that adjust prices asymmetrically in each 2 digit zip code area. Zip codes with numbers that are close to each other are roughly in the same part of the country. The figure shows that a substantial part of the stations adjust prices asymmetrically in all zip code areas and that areas with a high percentage are not close to each other. So asymmetrically pricing stations are present all over the country.

Table 3.3 Characteristics of the group with asymmetrically pricing stations and the group with all other stations

	Asymmetrically pricing group	All other stations group	Equality: p-value
Number of stations in group	897	1,468	
Brand indicators			
Share of comp-owned stats	53%	55%	0.18
Av % of comp-owned stats in 3 dig zip	45%	47%	0.14
Share of Brand A stats	11%	15%	0.02*
Share of Brand B stats	14%	10%	0.00**
Share of Brand C stats	27%	23%	0.04*
Share of Brand D stats	10%	13%	0.13
Share of Brand E stats	10%	12%	0.03*
Share of branded stats	73%	74%	0.81
Av concentration ratio 5 largest brands in 3 dig zip	0.62	0.62	0.79
Av % of stats with own brand in 3 dig zip	31%	30%	0.52
Av % of stats with largest brand in 3 dig zip	33%	33%	0.63
Location indicators			
Share of highway stats	14%	11%	0.05
Av % of highway stats in 3 dig zip	10%	8%	0.00**
Av size of population in 3 dig zip	34,358	34,492	0.89
Av car/population ratio in 3 dig zip	0.61	0.61	0.65
Share of stats in 2 dig zip next to German border	18%	16%	0.28
Share of stats in 2 dig zip next to Belgian border	13%	13%	0.76
Competitor indicators			
Av % of other asym pricing stats in 2 dig zip	39%	37%	0.01*
Av % of other asym pricing stats in 3 dig zip	40%	37%	0.00**
Av nr of stats in 2 dig zip	51	50	0.05*
Av nr of stats in 3 dig zip	8	8	0.93
Av nr of stats per 1,000 inhab in 2 dig zip	0.26	0.25	0.32
Av nr of stats per 1,000 inhab in 3 dig zip	0.29	0.30	0.86
Price indicators			
Av (retail price - spot price) for stat	€ 0.116	€ 0.114	0.23
Av (retail price - spot price) of other stats in 2 dig zip	€ 0.112	€ 0.113	0.06
Av (retail price - spot price) of other stats in 3 dig zip	€ 0.112	€ 0.112	0.64
Av % of days with price change	36%	36%	0.12

Table 3.3 continues on the next page

Table 3.3 (continued)

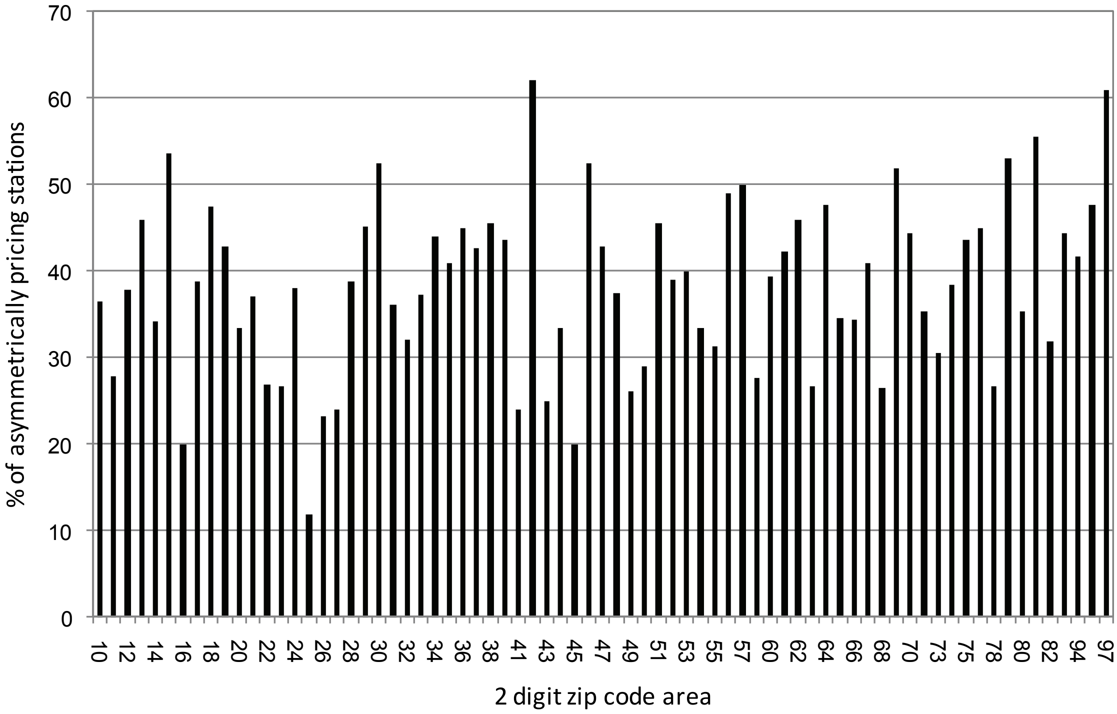
	Asymmetrically pricing group	All other stations group	Equality: p-value
Search intensity indicators			
Av rank reversal of a stat's area in 2 dig zip	0.051	0.050	0.07
Av rank reversal of a stat's area in 3 dig zip	0.055	0.056	0.47
Av spread of prices other stats in 2 dig zip	€ 0.028	€ 0.028	0.88
Av spread of prices other stats in 3 dig zip	€ 0.026	€ 0.026	0.92
Av % aged 60 or older in 3 dig zip	21%	21%	0.52
Av % unemployed in municipality	3%	3%	0.90
Av % immigrants in 3 dig zip	17%	17%	0.22
Av income per capita in 3 dig zip	€ 2,029	€ 2,033	0.70
Number of company-owned stations in group	472	814	
Av (retail price - spot price) for comp-owned stat	€ 0.117	€ 0.112	0.00**

Notes: * and ** indicate significance at the 5% and 1% levels, respectively. "Share of *x* stats" means share of stations in the group with characteristic *x*. "Av *x*" means average of characteristic *x* over all stations in the group.

A second characteristic that is statistically different is the percentage of highway stations in the 3 digit zip code area of a station. For asymmetrically pricing stations the average percentage of highway stations in the 3 digit zip code area is significantly higher than for all other stations. The size of the effect is moderate (10% vs. 8%). Third, stations that adjust prices asymmetrically are significantly more likely to be of certain brands, although the differences are not substantial.

The final significant result is the difference in markup for company-owned stations. I look at markups as a proxy for market power. Verlinda (2008) notes that stations with higher retail prices do not necessarily have higher markups and more local market power, because it is possible that oil companies do not charge the same wholesale price to all dealer-owned stations. However, for company-owned stations the difference between the retail price and spot market price is the true markup. The lowest line of Table 3.3 depicts the average difference between the retail price and spot market price for the groups of company-owned

Figure 3.6 Percentage of asymmetrically pricing stations per 2 digit zip code area



Note: The figure depicts only areas with 15 or more stations.

stations that do and do not set prices asymmetrically. It shows that company-owned stations that price asymmetrically have on average a statistically significant higher markup of 0.5 cent (the difference between the highest and lowest markup of the tested company-owned stations is 12.5 cents). If I consider all stations (company- and dealer-owned), then stations that adjust prices asymmetrically do not have a higher price on average.

All other characteristics in the table do not statistically differ between asymmetrically pricing stations and all other stations. All these characteristics and their intuition are relatively straightforward, with a few exceptions that I now discuss. First, I look at the *rank reversal of a station's area*. Retailers can increase search costs via their pricing behavior. If there is not a consistent price ranking of stations (i.e., stations often become cheaper or more expensive compared to each other), then there is a higher degree of imperfect information among consumers (higher search costs).[29] To measure this temporal price dispersion across stations (or say: the degree to which consumers are uncertain about which firms are cheap) I calculate the *rank reversals* (Chandra and Tappata (2008)).[30] More specifically, I calculate for each gasoline station the average of the rank reversals between all its competitors in the 2 and 3 digit zip code area where the station is located. This average rank reversal (say: the rank reversal of a station's area) is a proxy for the degree of uncertainty about prices in the market of this station (I exclude the station itself because if it adjusts prices asymmetrically, this might lead to a higher rank reversal). Table 3.3 presents the average rank reversal of a station's area for both groups of stations. There is no difference between the groups.

A second characteristic that is not straightforward is the *average spread of prices of other stations in an area*. I proxy station-specific search costs for a consumer by the price spread between stations. If there are still high potential gains of search in the area around a station, search costs in the market of that station must be high.[31] For each station I take the mean of the average price spread between all possible pairs of competitors in the zip code area. The table shows that there is no difference between the two groups.

The final characteristics that are not straightforward are the characteristics of consumers in the area around a gasoline station. The share of people in an area that are 60 years or older, unemployed, or immigrant is a proxy for the number of searchers (Lach (2007) argues that

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[29] According to standard search models (Varian (1980)), under imperfect information the ranking of retail prices differs over time. Retailers differentiate between consumers that are fully informed and ones that have to search for price quotations.

[30] Chandra and Tappata (2008) define the rank reversal as follows. The vector $s_{i,j}$ contains the price spread between two stations (i,j) over $T_{i,j}$ days such that station i has most often the highest price. The rank reversal between station i and j is the proportion of observations where $P_{j,t} > P_{i,t}$:

$$r_{i,j} = \frac{1}{T_{i,j}} \sum_{t=1}^{T_{i,j}} I_{\{P_{j,t} > P_{i,t}\}}$$

A rank reversal of 0.05 means that the station which has most often the lowest price, has at 5% of the observations the highest price.

[31] Chandra and Tappata (2008) show that in general the relation between search intensity and price dispersion is nonmonotonic.

immigrants can have different search costs). The results are similar for stations in both groups. Income is a measure of a consumer's opportunity cost of search. The table shows that income per capita is not higher around stations that adjust prices asymmetrically.

To summarize this section, I find that none of the characteristics in my data set differ substantially between stations that do and do not adjust prices asymmetrically. Although asymmetrically pricing stations differ in some aspects, the economic significance of these differences is small. None of the proxies provide strong encouragement for either the tacit collusion or the low search intensity hypothesis. Asymmetric pricing seems to be a phenomenon that occurs randomly in the population of gasoline stations.[32]

3.5 Conclusion

This chapter examines whether oil companies and gasoline stations adjust prices asymmetrically. It also studies differences in characteristics of stations that do and do not adjust prices asymmetrically.

None of the oil companies adjust suggested prices asymmetrically to changes in the spot market price. I do find heterogeneity in the way individual gasoline stations set prices. The majority of stations do not adjust prices asymmetrically, but 38% of the stations do. One day after a change in the spot market price, the asymmetry is substantial for these stations (on average 0.193 cent after a 1 cent shock), but this asymmetry disappears for most stations after one or two days. I do not find a clear pattern in the characteristics of asymmetrically pricing stations. Asymmetric pricing seems to be a phenomenon that

[32] I also perform the same analysis as in this section on stations that respond asymmetrically to the suggested price (see Appendix 3.B). I find that a substantial part of the stations that adjust their retail price asymmetrically to changes in the suggested price have the same brand. Of the stations that adjust prices asymmetrically, 39% have Brand A vs. 13% of all the other stations (p-value of the t-test for equality is 0.00). I cannot explain this result (remember from Figure 3.1 that the suggested price of Brand A responds symmetrically to the spot market price). Possibly, institutional factors like contracts between the oil company and gasoline stations play a role. Except the specific brand characteristics, none of the characteristics statistically differ between the two groups.

occurs randomly across individual gasoline stations. The analysis does not provide indications that strongly suggest that tacit collusion or a low search intensity is an important explanation for asymmetry.

In this study I use data on decisions of almost all individual decision makers in the Netherlands. These data have a similar frequency as pricing decisions and cost changes. The data set gives the possibility to study the asymmetric pricing behavior of individual firms and to measure the degree of heterogeneity. Previous research mainly focuses on asymmetry at the market level. I minimize a possible bias caused by aggregation over time and rule out a possible bias caused by aggregation over individuals. This microdata study shows that differences between individual firms are important for a proper understanding of asymmetric pricing.

Appendix 3.A Parameter estimates

Table 3.A1 Suggested price - spot market price: estimation results (Equation (3.1), (3.2), and (3.3))

	Brand A		Brand B		Brand C		Brand D		Brand E	
	Sym (3.2)	Asym (3.3)	Sym (3.2)	Asym (3.3)	Sym (3.2)	Asym (3.3)	Sym (3.2)	Asym (3.3)	Sym (3.2)	Asym (3.3)
Observations	546		546		546		546		546	
$\Delta Spot_{t-1}$	0.278 (0.031)		0.200 (0.027)		0.285 (0.028)		0.291 (0.031)		0.264 (0.031)	
$\Delta Spot^{+}_{t-1}$		0.294 (0.050)		0.212 (0.050)		0.297 (0.043)		0.349 (0.059)		0.267 (0.053)
$\Delta Spot^{-}_{t-1}$		0.262 (0.049)		0.185 (0.040)		0.270 (0.047)		0.230 (0.047)		0.259 (0.052)
$\Delta Spot_{t-2}$	0.396 (0.036)		0.508 (0.031)		0.494 (0.036)		0.378 (0.034)		0.498 (0.034)	
$\Delta Spot^{+}_{t-2}$		0.441 (0.056)		0.561 (0.050)		0.540 (0.050)		0.358 (0.065)		0.505 (0.054)
$\Delta Spot^{-}_{t-2}$		0.349 (0.064)		0.453 (0.047)		0.449 (0.071)		0.403 (0.051)		0.489 (0.055)
$\varepsilon^{*}_{i,t-1}$	-0.505 (0.044)		-0.521 (0.039)		-0.522 (0.033)		-0.467 (0.037)		-0.564 (0.041)	
$\varepsilon^{*+}_{i,t-1}$		-0.526 (0.082)		-0.535 (0.063)		-0.552 (0.052)		-0.483 (0.057)		-0.516 (0.061)
$\varepsilon^{*-}_{i,t-1}$		-0.483 (0.065)		-0.510 (0.064)		-0.492 (0.068)		-0.446 (0.073)		-0.620 (0.073)
	Long-run relation (3.1)		Long-run relation (3.1)		Long-run relation (3.1)		Long-run relation (3.1)		Long-run relation (3.1)	
$Spot_{t-2}$	1.006 (0.006)		1.009 (0.005)		1.003 (0.005)		0.998 (0.006)		0.983 (0.005)	
c^{*}_{i}	0.150 (0.002)		0.148 (0.002)		0.150 (0.002)		0.153 (0.002)		0.158 (0.002)	
$Time_t$ (*0.001)	0.003 (0.004)		0.012 (0.003)		0.004 (0.003)		0.008 (0.004)		0.019 (0.003)	
Mix_t	0.008 (0.001)		0.005 (0.001)		0.006 (0.001)		0.006 (0.001)		0.005 (0.001)	

Note: Between brackets are White heteroskedasticity-consistent standard errors.

Table 3.A2 Retail prices - spot market price: pooled estimation results (Equation (3.1'), (3.2'), and (3.3'))

	No lags (*k*=*l*=0; *v*=*w*=*x*=*y*=0)		One lag (*k*=*l*=1; *v*=*w*=*x*=*y*=1)		Three lags (*k*=*l*=3; *v*=*w*=*x*=*y*=3)	
	Sym (3.2')	Asym (3.3')	Sym (3.2')	Asym (3.3')	Sym (3.2')	Asym (3.3')
Stations	3,884		3,658		3,194	
Observations	1,264,639		1,052,741		798,435	
$\Delta Spot_{t-1}$	0.256 (0.021)		0.264 (0.023)		0.278 (0.025)	
$\Delta Spot^{+}_{t-1}$		0.320 (0.030)		0.322 (0.030)		0.345 (0.035)
$\Delta Spot^{-}_{t-1}$		0.189 (0.036)		0.202 (0.038)		0.216 (0.038)
$\Delta Spot_{t-2}$	0.332 (0.019)		0.358 (0.022)		0.362 (0.024)	
$\Delta Spot^{+}_{t-2}$		0.312 (0.029)		0.354 (0.033)		0.353 (0.031)
$\Delta Spot^{-}_{t-2}$		0.360 (0.030)		0.370 (0.036)		0.377 (0.041)
$\Delta Spot_{t-3}$			0.046 (0.020)		0.109 (0.020)	
$\Delta Spot^{+}_{t-3}$				0.017 (0.029)		0.081 (0.031)
$\Delta Spot^{-}_{t-3}$				0.085 (0.026)		0.141 (0.027)
$\Delta Spot_{t-4}$					0.100 (0.023)	
$\Delta Spot^{+}_{t-4}$						0.104 (0.041)
$\Delta Spot^{-}_{t-4}$						0.103 (0.028)
$\Delta Spot_{t-5}$					0.088 (0.020)	
$\Delta Spot^{+}_{t-5}$						0.085 (0.026)
$\Delta Spot^{-}_{t-5}$						0.076 (0.032)
$\Delta P_{i,t-1}$			-0.137 (0.014)		-0.194 (0.016)	
$\Delta P^{+}_{i,t-1}$				-0.126 (0.018)		-0.179 (0.020)
$\Delta P^{-}_{i,t-1}$				-0.151 (0.016)		-0.212 (0.019)
$\Delta P_{i,t-2}$					-0.085 (0.014)	
$\Delta P^{+}_{i,t-2}$						-0.076 (0.017)
$\Delta P^{-}_{i,t-2}$						-0.092 (0.019)
$\Delta P_{i,t-3}$					-0.040 (0.012)	
$\Delta P^{+}_{i,t-3}$						-0.030 (0.014)
$\Delta P^{-}_{i,t-3}$						-0.053 (0.015)
$\varepsilon^{*}_{i,t-1}$	-0.282 (0.008)		-0.252 (0.010)		-0.208 (0.009)	
$\varepsilon^{*+}_{i,t-1}$		-0.287 (0.016)		-0.253 (0.016)		-0.224 (0.014)
$\varepsilon^{*-}_{i,t-1}$		-0.276 (0.014)		-0.249 (0.014)		-0.191 (0.013)
	Long-run relation (3.1')					
$Spot_{t-2}$	0.993 (0.007)					
Mean of c^{*}_{i}	-0.112 (0.002)					
$Time_t$ (*0.001)	0.005 (0.003)					
Mix_t	0.004 (0.001)					

Note: Between brackets are Driscoll-Kraay standard errors.

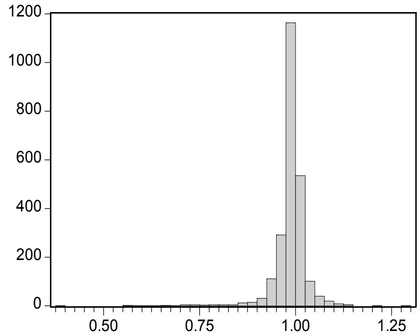
Table 3.A3 Retail prices - suggested prices: pooled estimation results (Equation (3.B1), (3.B2), and (3.B3))

	No lags (k=l=0; v=w=x=y=0)		One lag (k=l=1; v=w=x=y=1)		Three lags (k=l=3; v=w=x=y=3)	
	Sym (3.B2)	Asym (3.B3)	Sym (3.B2)	Asym (3.B3)	Sym (3.B2)	Asym (3.B3)
Stations	2,269		2,193		2,045	
Observations	951,652		828,718		661,407	
$\Delta Sug_{i,t}$	0.826 (0.010)		0.841 (0.010)		0.855 (0.010)	
$\Delta Sug^{+}_{i,t}$		0.844 (0.012)		0.860 (0.012)		0.876 (0.012)
$\Delta Sug^{-}_{i,t}$		0.802 (0.016)		0.816 (0.015)		0.830 (0.016)
$\Delta Sug_{i,t-1}$			0.244 (0.010)		0.358 (0.012)	
$\Delta Sug^{+}_{i,t-1}$				0.237 (0.012)		0.356 (0.015)
$\Delta Sug^{-}_{i,t-1}$				0.252 (0.015)		0.363 (0.017)
$\Delta Sug_{i,t-2}$					0.235 (0.011)	
$\Delta Sug^{+}_{i,t-2}$						0.221 (0.012)
$\Delta Sug^{-}_{i,t-2}$						0.253 (0.016)
$\Delta Sug_{i,t-3}$					0.130 (0.010)	
$\Delta Sug^{+}_{i,t-3}$						0.106 (0.011)
$\Delta Sug^{-}_{i,t-3}$						0.154 (0.017)
$\Delta P_{i,t-1}$			-0.259 (0.008)		-0.373 (0.011)	
$\Delta P^{+}_{i,t-1}$				-0.258 (0.011)		-0.380 (0.014)
$\Delta P^{-}_{i,t-1}$				-0.259 (0.013)		-0.368 (0.015)
$\Delta P_{i,t-2}$					-0.230 (0.008)	
$\Delta P^{+}_{i,t-2}$						-0.220 (0.008)
$\Delta P^{-}_{i,t-2}$						-0.242 (0.010)
$\Delta P_{i,t-3}$					-0.131 (0.007)	
$\Delta P^{+}_{i,t-3}$						-0.109 (0.008)
$\Delta P^{-}_{i,t-3}$						-0.152 (0.009)
$\varepsilon^{*}_{i,t-1}$	-0.252 (0.007)		-0.186 (0.006)		-0.135 (0.005)	
$\varepsilon^{*+}_{i,t-1}$		-0.243 (0.011)		-0.178 (0.009)		-0.134 (0.009)
$\varepsilon^{*-}_{i,t-1}$		-0.260 (0.007)		-0.192 (0.007)		-0.135 (0.007)
	Long-run relation (3.B1)					
$Sug_{i,t}$	0.991 (0.001)					
Mean of c^{*}_{i}	-0.033 (0.001)					

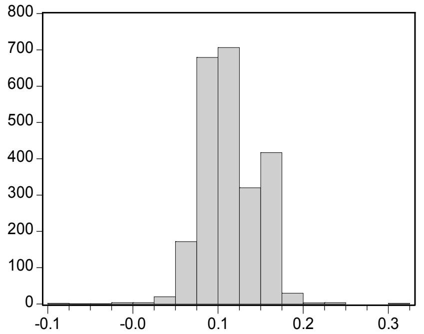
Note: Between brackets are Driscoll-Kraay standard errors.

Figure 3.A1 Estimation results Equation (3.1')

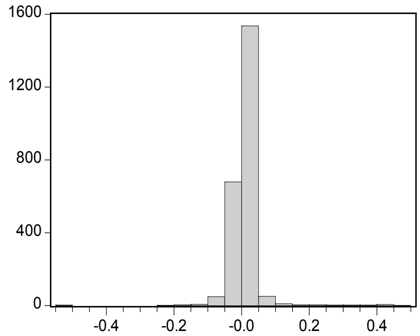
$Spot_{t-2}$ (mean=0.988, stations=2,365)



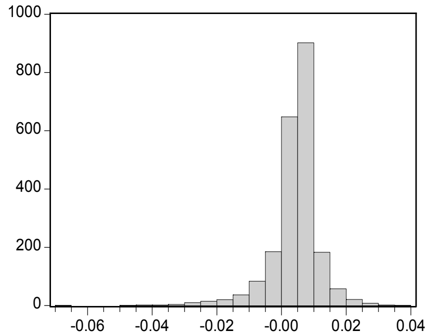
c^*_i (mean=0.113, stations=2,365)



$Time_t$ (*0.001) (mean=0.006, stations=2,365)



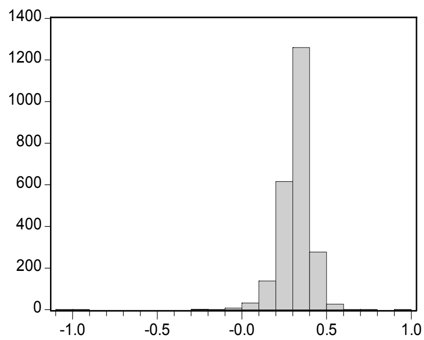
Mix_t (mean=0.004, stations=2,184)



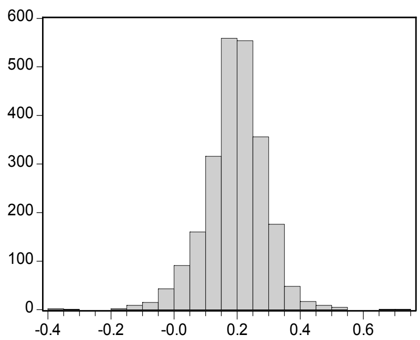
Note: Estimated parameter on horizontal axis, number of stations on vertical axis.

Figure 3.A2 Estimation results Equation (3.3')

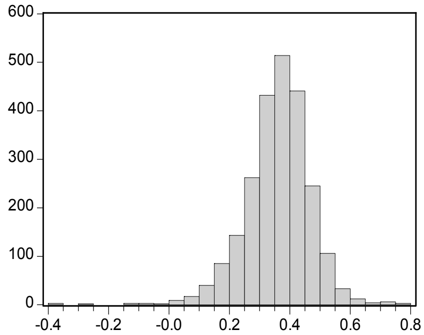
$\Delta Spot^+_{i,t-1}$ (mean=0.320, stations=2,365)



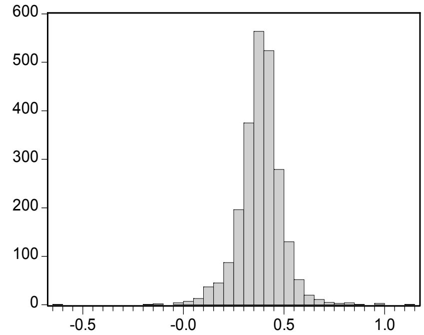
$\Delta Spot^-_{i,t-1}$ (mean=0.195, stations=2,365)



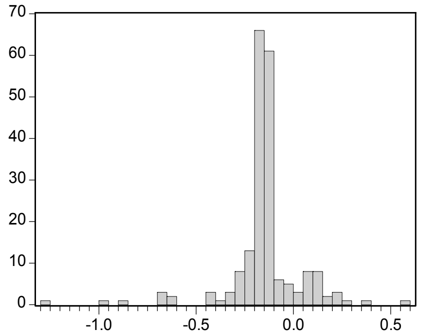
$\Delta Spot^{+}_{i,t-2}$ (mean=0.360, stations=2,365)



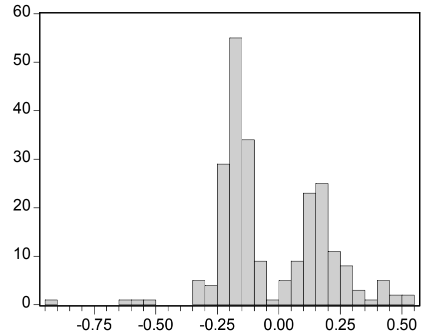
$\Delta Spot^{-}_{i,t-2}$ (mean=0.383, stations=2,365)



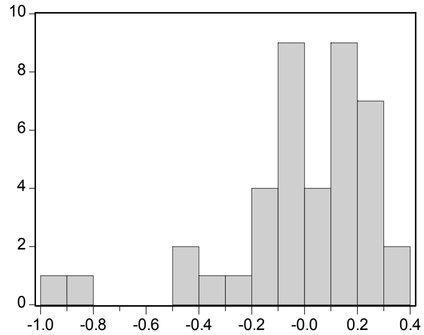
$\Delta Spot^{+}_{i,t-3}$ (mean=-0.148, stations=201)



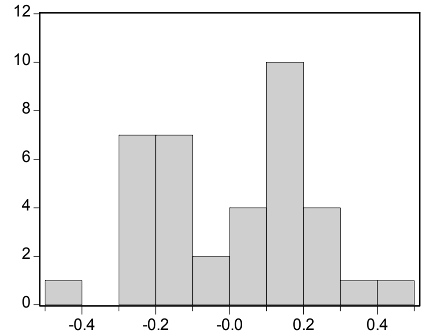
$\Delta Spot^{-}_{i,t-3}$ (mean=-0.035, stations=235)



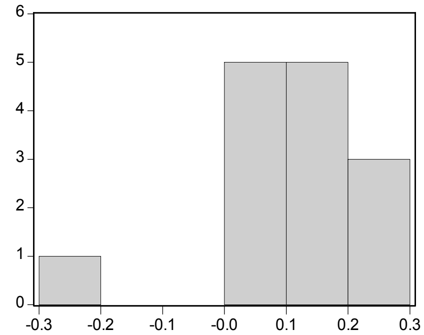
$\Delta Spot^{+}_{i,t-4}$ (mean=-0.013, stations=41)



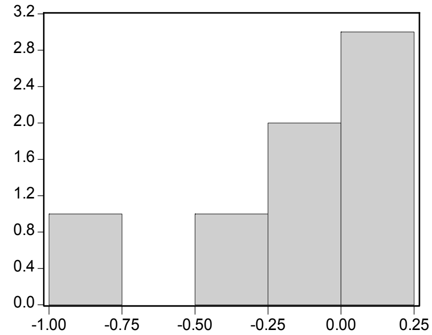
$\Delta Spot^{-}_{i,t-4}$ (mean=0.006, stations=37)



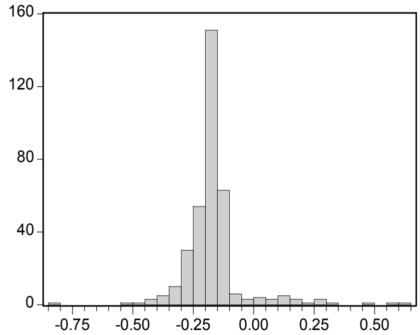
$\Delta Spot^{+}_{i,t-5}$ (mean=0.104, stations=14)



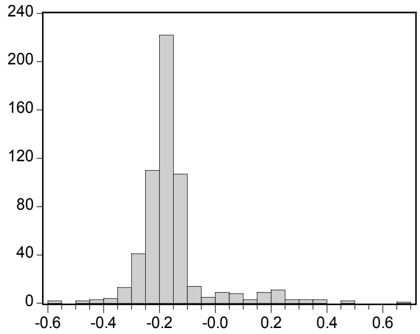
$\Delta Spot^{-}_{i,t-5}$ (mean=-0.156, stations=7)



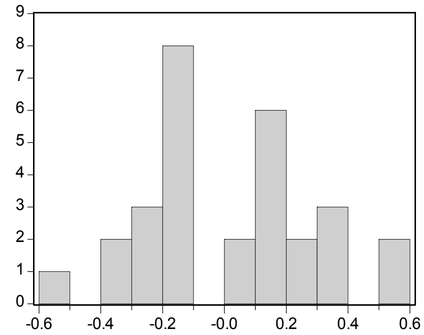
$\Delta P^{+}_{i,t-1}$ (mean=-0.166, stations=351)



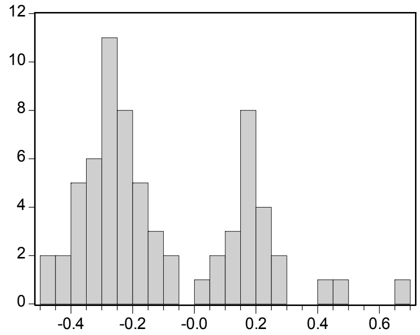
$\Delta P^{-}_{i,t-1}$ (mean=-0.154, stations=575)



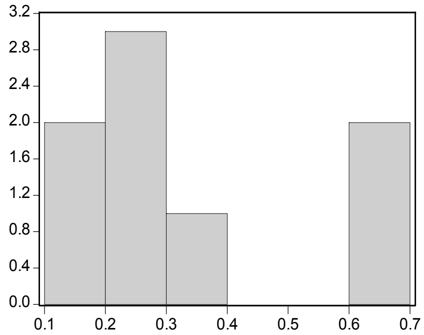
$\Delta P^{+}_{i,t-2}$ (mean=0.018, stations=29)



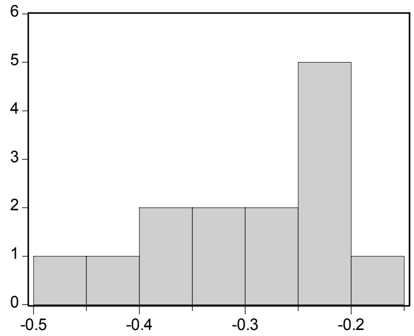
$\Delta P^{-}_{i,t-2}$ (mean=-0.103, stations=67)



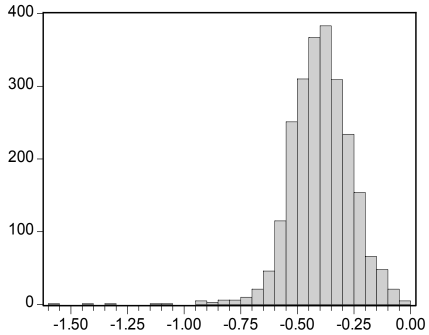
$\Delta P^{+}_{i,t-3}$ (mean=0.343, stations=8)



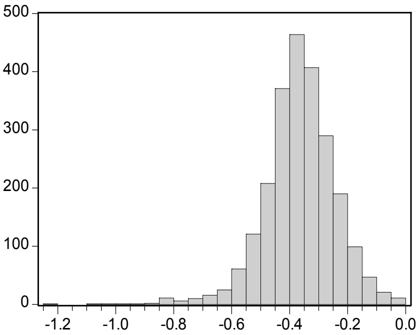
$\Delta P^{-}_{i,t-3}$ (mean=-0.296, stations=14)



$\varepsilon^{*+}_{i,t-1}$ (mean=-0.396, stations=2,365)



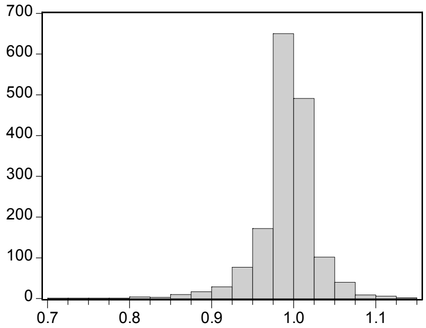
$\varepsilon^{*-}_{i,t-1}$ (mean=-0.365, stations=2,365)



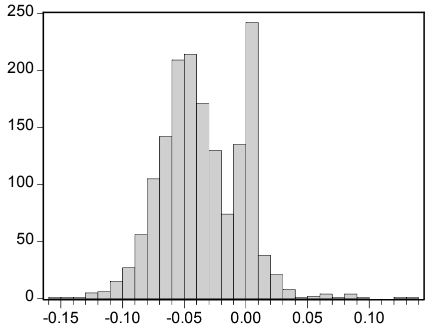
Note: Estimated parameter on horizontal axis, number of stations on vertical axis.

Figure 3.A3 Estimation results Equation (3.B1)

$Sug_{i,t}$ (mean=0.992, stations=1,616)



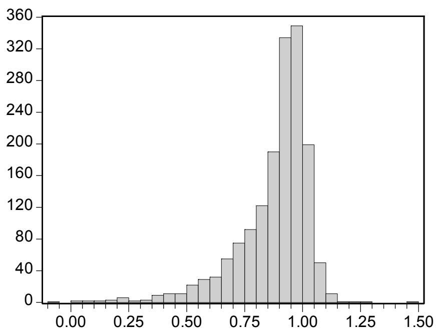
c^*_i (mean=-0.035, stations=1,616)



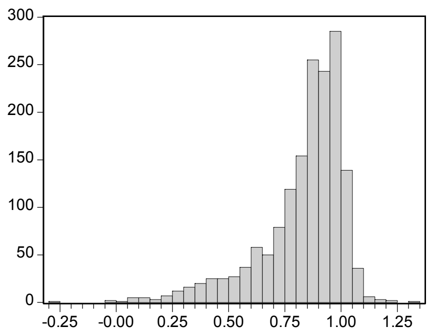
Note: Estimated parameter on horizontal axis, number of stations on vertical axis.

Figure 3.A4 Estimation results Equation (3.B3)

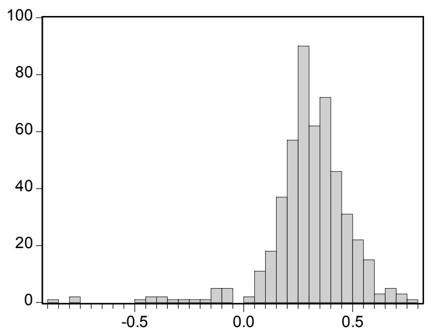
$\Delta Sug^+_{i,t}$ (mean=0.878, stations=1,616)



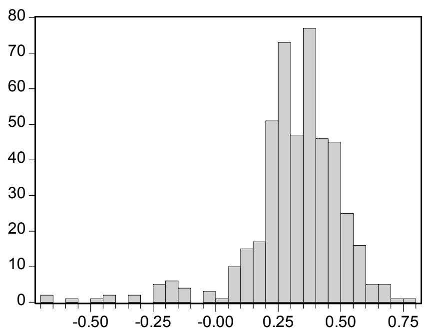
$\Delta Sug^-_{i,t}$ (mean=0.832, stations=1,616)



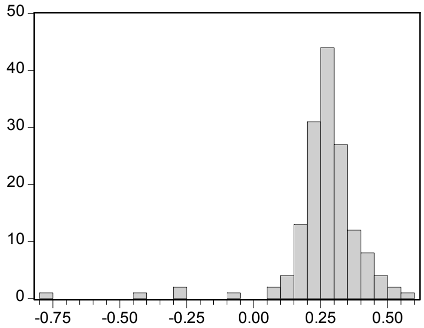
$\Delta Sug^+_{i,t-1}$ (mean=0.303, stations=497)



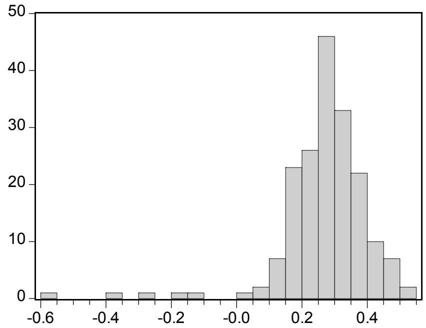
$\Delta Sug^-_{i,t-1}$ (mean=0.316, stations=461)



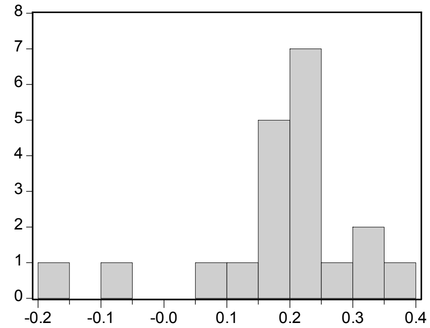
$\Delta Sug^{+}_{i,t-2}$ (mean=0.262, stations=153)



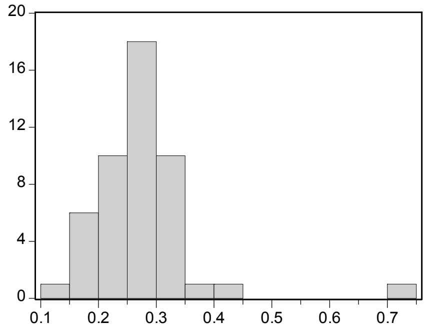
$\Delta Sug^{-}_{i,t-2}$ (mean=0.270, stations=184)



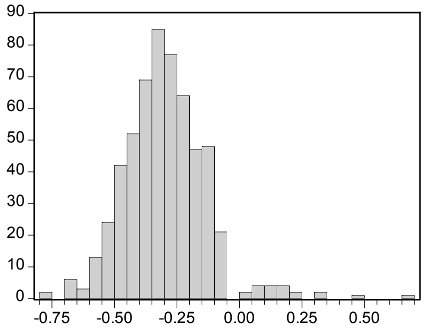
$\Delta Sug^{+}_{i,t-3}$ (mean=0.185, stations=20)



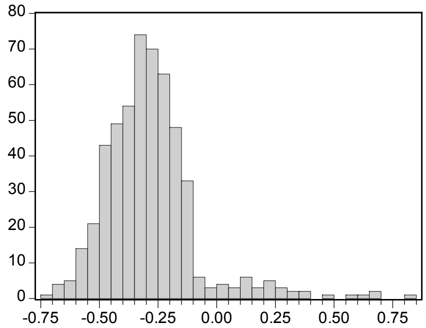
$\Delta Sug^{-}_{i,t-3}$ (mean=0.273, stations=48)



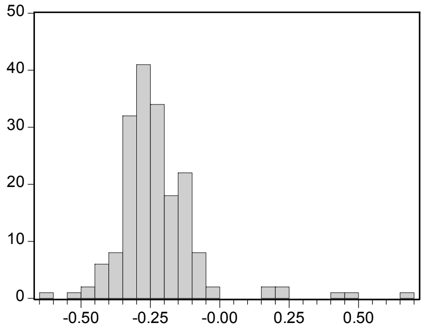
$\Delta P^{+}_{i,t-1}$ (mean=-0.299, stations=573)



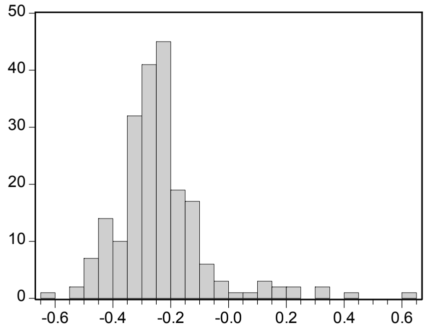
$\Delta P^{-}_{i,t-1}$ (mean=-0.285, stations=522)



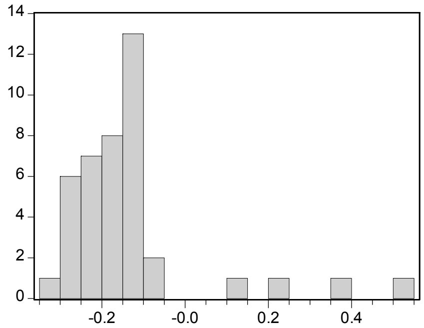
$\Delta P^{+}_{i,t-2}$ (mean=-0.227, stations=182)



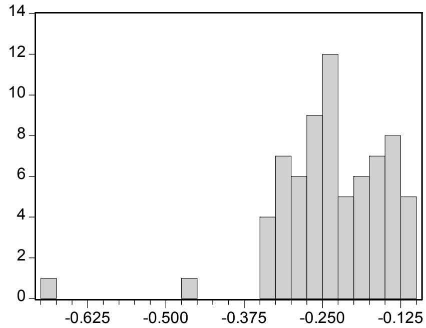
$\Delta P^{-}_{i,t-2}$ (mean=-0.235, stations=210)



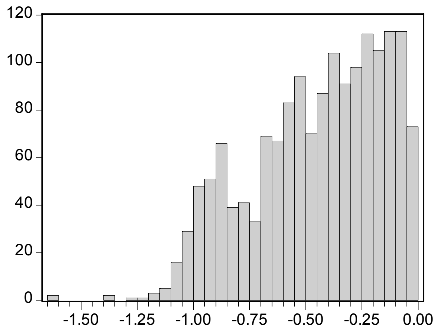
$\Delta P^{+}_{i,t-3}$ (mean=-0.130, stations=41)



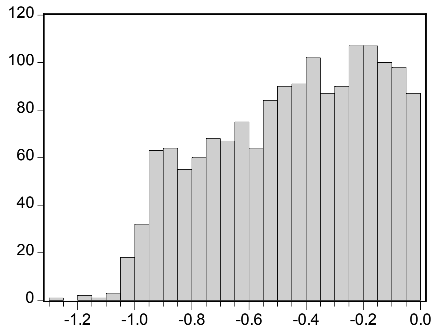
$\Delta P^{-}_{i,t-3}$ (mean=-0.232, stations=71)



$\varepsilon^{*+}_{i,t-1}$ (mean=-0.447, stations=1,616)



$\varepsilon^{*-}_{i,t-1}$ (mean=-0.448, stations=1,616)



Note: Estimated parameter on horizontal axis, number of stations on vertical axis.

Appendix 3.B Do gasoline stations respond asymmetrically to changes in the suggested price?

In Section 3.3 I study whether gasoline stations respond asymmetrically to changes in the spot market price. In this appendix I study whether stations respond asymmetrically to changes in the suggested price of their oil company. Since suggested prices are only available for the five largest oil companies, I only use stations that operate under the brand of one of the five largest oil companies (2,318 of the 4,004 stations in the sample). Like in Section 3.3, I estimate an asymmetric error correction model. The long-run relation between the suggested price and retail price is:

$$P_{i,t} = \alpha_i^* Sug_{i,t} + c_i^* + \varepsilon_{i,t}^* \tag{3.B1}$$

where $Sug_{i,t}$ now refers to the suggested price of the oil company of the brand of station *i* on day *t*. Moreover, c_i^* now reflects the average difference between the retail price and the suggested price. First, I specify a symmetric relation between the retail price and suggested price:[33]

$$\Delta P_{i,t} = \sum_{j=0}^{k} \alpha_{i,j} \Delta Sug_{i,t-j} + \sum_{j=1}^{l} \beta_{i,j} \Delta P_{i,t-j} + \gamma_i \varepsilon_{i,t-1}^* + \mu_{i,t} \tag{3.B2}$$

I also specify an asymmetric relation:

[33] Gasoline stations could use more recent information on the spot market price than is available in the suggested price. On the day that oil companies decide on the suggested price (*t*-1), they only have limited knowledge on the spot market price of that day (see Section 3.1 and Footnote 20). However, at the moment that gasoline stations decide on their retail price (the morning of *t*), they could know the spot market price of day *t*-1. The data do not suggest that retailers widely use this information in practice.

$$\Delta P_{i,t} = \sum_{j=0}^{v} \alpha_{i,j}^{+} \Delta Sug_{i,t-j}^{+} + \sum_{j=0}^{w} \alpha_{i,j}^{-} \Delta Sug_{i,t-j}^{-}$$

$$+ \sum_{j=1}^{x} \beta_{i,j}^{+} \Delta P_{i,t-j}^{+} + \sum_{j=1}^{y} \beta_{i,j}^{-} \Delta P_{i,t-j}^{-} + \gamma_i^{+} \varepsilon_{i,t-1}^{*+} + \gamma_i^{-} \varepsilon_{i,t-1}^{*-} + \mu_{i,t} \tag{3.B3}$$

As in Section 3.3, I estimate the equations when all gasoline stations are pooled and for each individual gasoline station. I use the same estimation methods as in Section 3.3.

3.B.1 All stations pooled

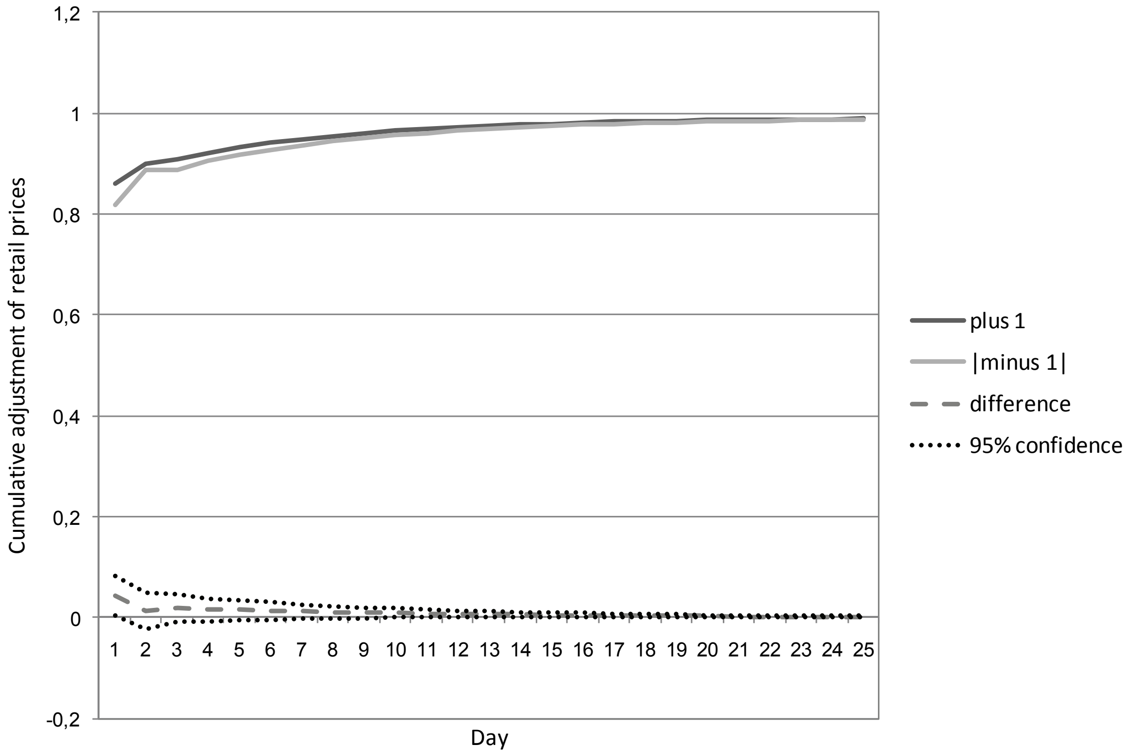
I first estimate the pooled equation. The panel cointegration test of Kao (1999) reveals homogeneous cointegration between retail prices and suggested prices. Table 3.A3 in Appendix 3.A shows estimation results. As in Section 3.3, I present several specifications. The estimated coefficient for the long-run impact of the suggested price is 0.991.

Figure 3.B1 shows the cumulative adjustment function for the specification with v=w=x=y=1 (the cumulative adjustment functions for other specifications are similar). It shows that there is significant asymmetry. The difference between the cumulative changes in the retail prices is positive and significant on the first day after the shock. On day 1, the pass-through of a 1 cent change in the suggested price is 0.860 cent after an increase and only 0.816 cent after a decrease. After day 1 this difference declines slowly over time.[34] After 16 days, retail prices have adsorbed more than 97.5% of both the positive and negative shock.[35] I take a look at the disaggregated level in the next paragraphs.

[34] The difference between the positive and negative shock is also statistically different from 0 on days 14 up to 19.

[35] After 25 days, the sum of the differences between the positive and negative cumulative adjustment equals 0.215 cent. Analogous to the back-of-the-envelope calculation in Section 3.3.1, all consumers together pay 30,716 euros more after a 1 cent increase in the suggested price than they save after an equal decrease.

Figure 3.B1 Cumulative adjustment of retail prices (after suggested price change, pooled estimation)



3.B.2 Individual stations

I first estimate Equation (3.B1) and afterward Equation (3.B3) for 1,616 individual gasoline stations.[36] Figure 3.A3 and 3.A4 (Appendix 3.A) contain distributions of the parameter estimates. The average estimated long-run impact of the suggested price on the

[36] The sample contains 2,318 stations with the brand of one of the five largest oil companies. For 1,800 stations there is enough data to estimate both Equation (3.B1) and (3.B3). I exclude 42 stations because the residual-based test for cointegration could not reject the null of no cointegration in Equation (3.B1) (all price series of the estimated stations are integrated of order 1). Furthermore, I exclude 45 stations because the estimated γ_i^+ or γ_i^- in Equation (3.B3) is larger than 0 or smaller than -2 and 97 stations for which 20 or fewer observations that differ from 0 are available for estimating one of the parameters in Equation (3.B3) (more restrictive conditions do not change results much). There are 1,616 stations left. I correct for 651 of these 1,616 stations the standard errors for heteroskedasticity and for 857 stations for heteroskedasticity and serial correlation.

Table 3.B1 Percentage of stations that adjust prices asymmetrically (after a change in the suggested price) and the total length of the asymmetric part of the transmission process

	plus>minus		minus>plus	
	number of stations	% of stations	number of stations	% of stations
Total	1,616		1,616	
0 days	1,254	78%	1,441	89%
1 day or more	362	22%	175	11%
1 day	147	9%	80	5%
2 days	62	4%	25	2%
3 days	47	3%	14	1%
4 days	21	1%	8	0%
5 days	11	1%	4	0%
6 days or more	74	5%	44	3%

retail price is 0.992.[37] I calculate a cumulative adjustment function for every gasoline station.

First, I calculate the percentage of gasoline stations that respond asymmetrically to changes in the suggested price. I count for each station the number of days on which the cumulative change in the retail price after the positive shock is significantly larger than the cumulative change in the retail price after the negative shock. Table 3.B1 reports the results. Many gasoline stations do not adjust prices asymmetrically, but a substantial part of the gasoline stations do. The table shows that for 22% of the gasoline stations the transmission process is asymmetric on at least one day. However, only a small part of the transmission process of these stations is asymmetric. For the majority of the stations that adjust their prices asymmetrically, the asymmetry exists for only 1 day in total.

Figure 3.B2 shows on *which* days the transmission processes of the gasoline stations are asymmetric. For each day the figure shows the number of stations for which the difference

[37] The right part of Figure 3.A3 shows the average difference between the suggested price and retail price. There are stations that charge on average the suggested price and stations that give on average a “discount” on the suggested price (for these stations the average “discount” is around 5 cents). Chapter 2 discusses the coordinating effect of suggested prices.

between the cumulative price change after the positive and negative shock is positive and significantly different from 0. Most of the asymmetry takes place directly after the shock. On the first day after the shock, for 228 out of 1,616 gasoline stations (14%) a positive shock has a significantly larger impact on the retail price than a negative shock. This number decreases over time. After a week the difference is positive and significant for only 77 stations.

Figure 3.B3 reports the size of the asymmetric effect. For each day I calculate the average difference between the cumulative retail price adjustments for the 22% of the gasoline stations that price asymmetrically. The average difference is 0.205 cent directly after the shock, but declines over time. Figure 3.B3 also contains the daily average difference over all gasoline stations. It differs substantially from the mean of stations that adjust prices asymmetrically. On day 1 the mean difference over all stations equals 0.046 cent (close to the value from the pooled estimation). After day 1, it decreases rapidly toward zero. On day 1, the estimated extent of the asymmetry is 0.159 cent (348%) larger if I only consider stations that adjust prices asymmetrically.

Figure 3.B4 shows the length of the transmission process after a positive shock. The process takes after a positive shock on average 6.1 days for asymmetrically pricing stations and 5.1 days for other stations. I calculate the length of the transmission process after a negative shock as well. For asymmetrically pricing stations the transmission process is faster after a positive shock (on average 2.4 days). For these stations the transmission process of both positive and negative shocks takes longer, but also the difference in length of the two transmission processes is larger. For the other stations the transmission process is on average just a bit faster after a positive shock (0.2 days). These results are more in

Figure 3.B2 The number of stations that respond asymmetrically after a change in the suggested price per day

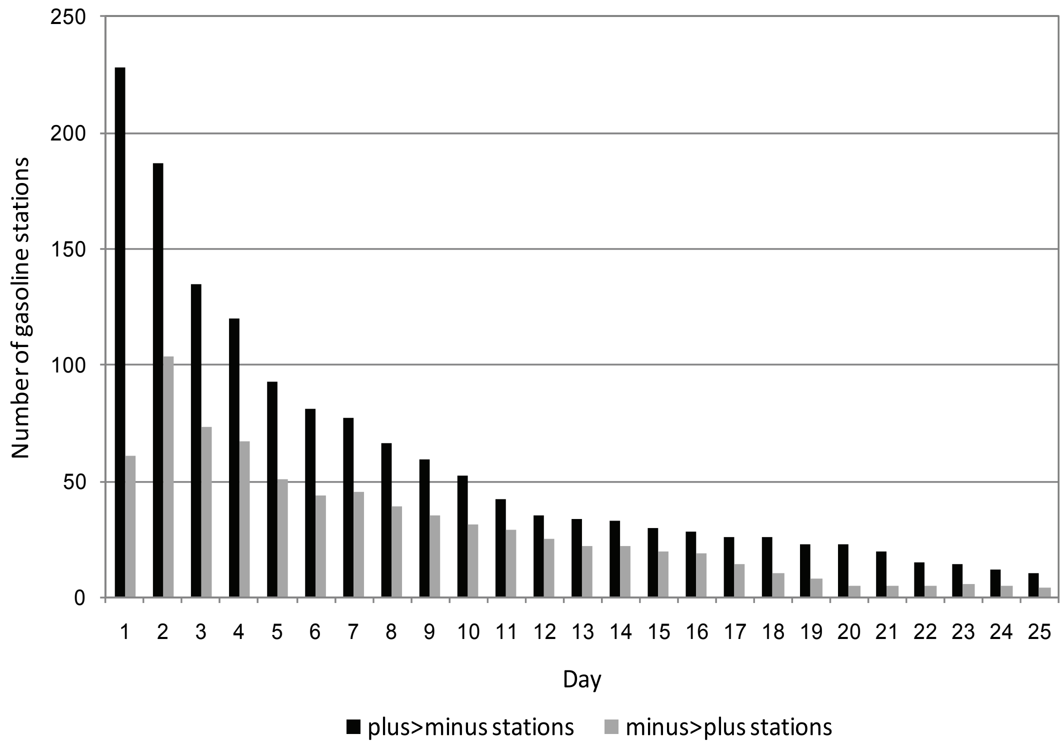


Figure 3.B3 Average extent of asymmetry after a change in the suggested price (difference between the cumulative adjustments)

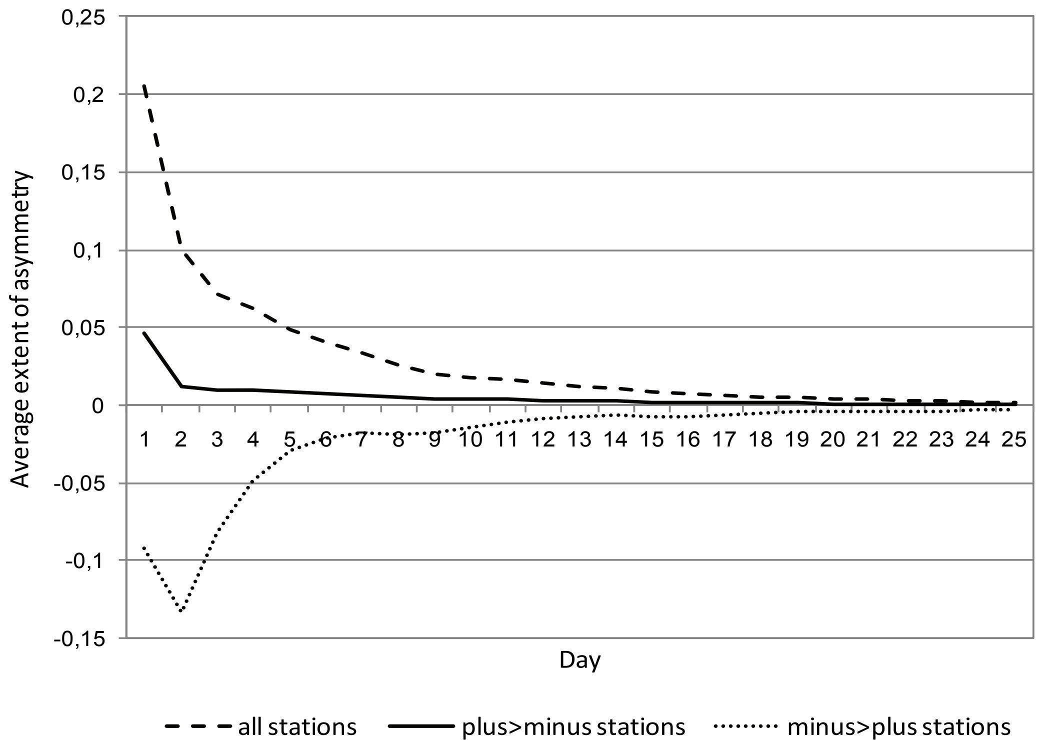
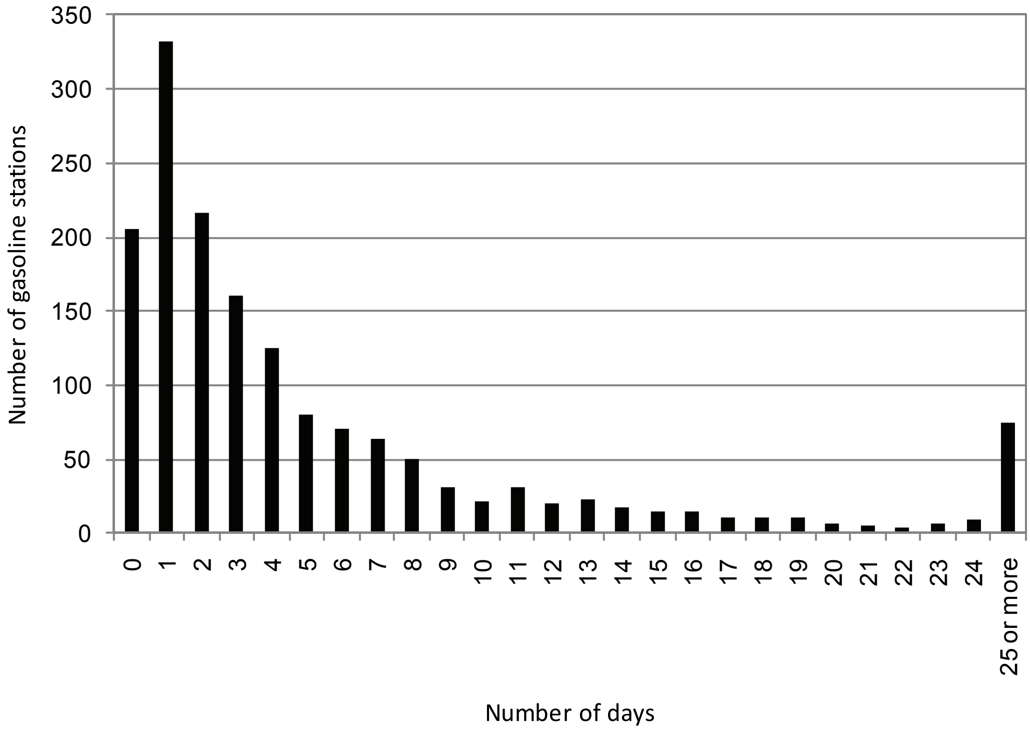


Figure 3.B4 Length of the transmission process after a positive shock in the suggested price



line with expectations than the properties of the estimated transmission processes in Section 3.3.[38]

Next, I look at gasoline stations that respond faster to *decreases* than to increases in the suggested price. Table 3.B1 reports the percentage of gasoline stations for which on at least one day the difference between the cumulative price change after a positive shock and the cumulative price change after a negative shock is negative and significantly different from 0. This is 11%.[39] For about half of these stations this effects lasts for one day. Figure 3.B2 shows the number of stations for which the difference is negative and significant on each

[38] Like in Section 3.3, I find that according to the estimations per station the transmission process is on average much shorter than according to the pooled estimation. The maximum length of the transmission process after a positive shock and after a negative shock is according to the pooled estimation 15 days. This maximum is on average 7.2 days according to the estimations per station.

[39] There are 15 stations for which the difference between the cumulative price change after a positive and a negative shock is both significantly positive and significantly negative at least once.

day. On day 2 the difference is significantly negative for 104 gasoline stations. This number declines over time. Figure 3.B3 reports for the 11% of the stations the size of the average daily difference. The difference between a negative shock and a positive shock is on average 0.092 cent on the first day after the shock, but declines over time.

In Section 3.3 I found that 38% of the gasoline stations adjust their prices asymmetrically to changes in the spot market price. In this appendix I find that 22% of the gasoline stations respond asymmetrically to changes in the suggested price. The latter analysis excludes stations without the brand of one of the five largest oil companies, but this difference does not cause the higher percentage in Section 3.3. Of the 1,616 stations that I use in this appendix, 39% respond asymmetrically to changes in the spot market price (and 6% respond faster to decreases than increases in the spot market price).

As a robustness check for Equation (3.B3), I estimate the same alternative specifications as in Section 3.3 for the 1,611 stations for which I can estimate all specifications (see Table 3.2 for the specifications). The percentage of gasoline stations that adjust prices asymmetrically varies between 13% and 22%. Depending on the specification, the percentage of stations that respond faster to decreases than to increases in the suggested price is between 2% and 11%.

Chapter 4

Price Setting and European Integration Policy: A Short History of Price Level Convergence in Europe*

Joint work with Ad C.J. Stokman

During the last five decades, European countries made a huge effort to integrate their national markets. The signing of the Treaty of Rome on the establishment of the European Economic Community 50 years ago (1957), the completion of the Single Market (1993), and the recent introduction of the euro (1999) have been milestones in the process toward economic, monetary, and political unification of Europe. The demolition of "border effects" (Engel and Rogers (1996)) makes Europe a particularly interesting case for studying price level convergence. The two main objectives of this chapter are (i) detecting general trends in price level dispersion starting from the earlier days of economic cooperation in Europe and (ii) the identification of the main determinants behind this process. In other words: how successful has European integration policy been?

Due to limited availability of data on absolute price levels, little is known about the *long-term* development of European price level dispersion. Regular price data collected by national statistical agencies are mainly published in terms of indices and are for that reason not suitable for international comparisons. Since 1995, Eurostat publishes price level differences between countries (see Allington, Kattuman, and Waldmann (2005)), but this period is too short to answer our questions. Also, from the Organisation for Economic Co-

* This chapter is a version of the paper "A Short History of Price Level Convergence in Europe", *Journal of Money, Credit and Banking*, March-April 2009, Vol. 41, No. 2-3, pp. 461-477.

operation and Development's (OECD) International Comparison Project some comparable national price levels are known, but again country and time coverage are limited. To avoid these problems, several studies use microdata.

First of all, there are studies that focus on one specific product, like automobiles (Goldberg and Verboven (2005)) or hamburgers (Parsley and Wei (2007)). Although these studies produce interesting insights, such an approach does not help much in detecting general price level trends. The second type of research uses data sets that cover a broad set of products. Engel and Rogers (2004) and Rogers (2007) use a city data set provided by the Economist Intelligence Unit (EIU), which is available from 1990 onward. Crucini, Telmer, and Zachariadis (2005) (henceforth CTZ) use an extensive Eurostat microdata set that covers 4 individual years (1975, 1980, 1985, and 1990). Both studies provide interesting insights but cover just parts of the European integration process.

For our historical investigation into the trends and determinants of price level dispersion in Europe, long time spans are needed. To that end, we scale harmonized indices of consumer prices (HICP) back to 1960 on the basis of occasional measurements of price level differences between countries. So we convert harmonized *indices* of consumer prices into proxies of *absolute* price levels. Chen and Devereux (2003) use a similar method to construct price level data for U.S. cities.[1]

The calculation of these long price level series allows us to construct time series on price level dispersion for almost the complete period of European integration and to uncover the determinants of price level dispersion over time. Moreover, we can compare developments in the European Union (EU) and the Economic and Monetary Union (EMU) with long-term developments in other regions, like the United States. The United States is a natural benchmark, as it has been a political, cultural, and monetary union for a long period of

[1] Cecchetti, Mark, and Sonora (2002) and Engel and Rogers (2001), among others, also examine price level dispersion on the basis of consumer price indices (CPI), but their studies are based on differences in inflation rates, not absolute price levels.

time. We also compare European-wide developments with those in the former DM zone (Germany, Austria, Belgium, Luxembourg, and the Netherlands). Such a comparison might help to understand the significance of monetary unions relative to customs unions since the DM zone was already an area of monetary and exchange rate stability long before the EMU started. Our main result is that European price levels converged over much of the last 40 to 50 years, while in the United States price level dispersion remained more or less stable. Moreover, price levels converged faster in the DM zone than in the EMU.

To identify the determinants of price level dispersion and to get an indication of their contributions to the dispersion level and its decline, we use the model that CTZ apply to European cross-sectional micro price data. In that model, retail price dispersion is a function of dispersion of nontraded input costs (e.g., wages) and dispersion of traded input costs. Our data set allows us to introduce a time dimension to the CTZ framework for price level dispersion. A back-of-the-envelope calculation suggests that indirect tax rate harmonization, convergence of nontraded input costs, and convergence of traded input costs (in the form of exchange rate stability and increased openness) all contributed to European price level convergence.

The macroapproach may be subject to a number of shortcomings. Consumption baskets are not completely identical across EU countries. Furthermore, the composition of consumption baskets changes throughout time, as products disappear or are replaced by new ones. Moreover, aggregate HICP might be subject to a *summation bias*, that is, different price level movements in HICP subcategories, which may average out or dominate. In this chapter, we take a closer look at these and other issues. We conclude that, as far as we can judge, our approximation of price levels is reliable.

As mentioned before, there are studies that investigated similar questions either in the context of specific markets using product-level data, or for sets of products for only subperiods of our sample. However, to our knowledge, this is the first study that provides documentation of the evolution of price level dispersion in Europe and its determinants over a long period based on a representative basket of products.

The remainder of the chapter is organized as follows. Section 4.1 introduces our dispersion measure and briefly discusses the (marginally) adapted CTZ model. Section 4.2 describes the data. In Section 4.3 new evidence of European price level convergence at the aggregate and one-digit HICP product level is presented. Section 4.4 studies the main factors driving price level convergence. The reliability of our methodology and comparisons with other studies are discussed in Section 4.5. Section 4.6 concludes.

4.1 Model

In this section, we introduce the price level dispersion measure and theoretical framework. These are based on CTZ, although some modifications are made to study developments over time instead of cross-country differences.

First, we define the price level dispersion measure. Say a basket of products in country *j* at time *t* has price level P_{jt} (price levels from all *n* countries are expressed in the same currency, a product basket subscript is omitted for simplicity). Price level dispersion at time *t* is measured by the cross-country standard deviation of $\log P_{jt}$ (short notation $\sigma(x_t) = \sigma(\log X_{jt} \mid t)$):

$$\sigma(p_t) = \sigma(\log P_{jt} \mid t) = \sqrt{\frac{1}{n}\sum_{j=1}^{n}(\log P_{jt} - \frac{1}{n}\sum_{i=1}^{n}\log P_{it})^2} \tag{4.1}$$

Note that the choice of the common currency in which price levels are expressed does not affect the size of the dispersion measure. In Section 4.3 the evolution of price level dispersion will be studied.

Second, a theoretical framework is needed for studying the determinants of price level dispersion. Following CTZ, the production of a final product requires both traded and nontraded inputs. For example, a "traded good" like a car requires both traded inputs (iron) and nontraded inputs (salesperson's labor and a shop). Similarly, a typical "nontraded good" like a haircut also needs traded inputs like a pair of scissors.

Production in country *j* at time *t* with traded and nontraded inputs is described by a Cobb-Douglas technology with constant returns to scale. There is perfect competition.

$$P_{jt}^{*} = W_{jt}^{\alpha} Q_{jt}^{1-\alpha} \tag{4.2}$$

where P_{jt}^{*} is the price level P_{jt} in country *j* at time *t* corrected for indirect taxation (rate τ_{jt}): $P_{jt}^{*} = P_{jt}/(1+\tau_{jt})$. Here, W_{jt} is the cost of the nontraded input in country *j* at time *t*, Q_{jt} is the cost of the traded input in country *j* at time *t*, and α is the share of nontraded inputs required for production.

From Equation (4.2) we can deduce the relation between the price level dispersion and its determinants, first by taking the logarithm of Equation (4.2):

$$\log P_{jt}^{*} = \alpha \log W_{jt} + (1-\alpha)\log Q_{jt} \tag{4.3}$$

Next, calculate the variance for given *t* across *n* countries (and rewrite):

$$\begin{aligned} Var(\log P_{jt}^{*} \mid t) = [\sigma(p_t^{*})]^2 &= [\alpha\sigma(w_t) + (1-\alpha)\sigma(q_t)]^2 \\ &+ 2\alpha(1-\alpha)\sigma(w_t)\sigma(q_t)[Cor(w_t, q_t) - 1] \end{aligned} \tag{4.4}$$

where $Cor(w_t, q_t) = Cor(\log W_{jt}, \log Q_{jt} \mid t)$. We do not have data to calculate $Cor(w_t, q_t)$ and therefore we ignore the second term.[2] This gives the following expression for $\sigma(p_t^*)$:

$$\sigma(p_t^*) = \alpha\sigma(w_t) + (1-\alpha)\sigma(q_t) \tag{4.5}$$

The dispersion of price levels (excluding indirect taxes) is higher if the dispersion of nontraded input costs and the dispersion of traded input costs are higher. The dispersion of traded input costs is expected to be higher if arbitrage costs are higher. In our further analysis, arbitrage costs are broken down in (i) exchange rate volatility (vol_t) and (ii) openness of a country group ($open_t$) that summarizes the development throughout time of all other trade costs like transportation costs, (non)tariff barriers, and information costs (Rogoff (1996)):

$$\sigma(q_t) = f(vol_t(+), open_t(-)) = \beta_0 + \beta_1 vol_t + \beta_2 open_t \tag{4.6}$$

Substituting Equation (4.6) into Equation (4.5), we get the following testable relation:

$$\sigma(p_t^*) = \alpha\sigma(w_t) + (1-\alpha)[\beta_0 + \beta_1 vol_t + \beta_2 open_t] \tag{4.7}$$

In Section 4.4, the determinants of price level dispersion will be studied via this framework.

[2] The second term is relatively small if there is a sufficiently high correlation between the logarithms of W_{jt} and Q_{jt}. We will come back to this point in Section 4.3, Footnote 13.

4.2 Data

4.2.1 Price level data

As mentioned before, European price level data are constructed via scaling standard HICP data. Aggregated HICP data for the former EU-15 members are available back to 1960.[3] Disaggregated HICPs are only available from 1995 onward. To capture long-term price level developments at the one-digit product level, we connect HICP subindices to their consumer price indices (CPI) counterparts for the period 1980-1995.[4]

To compare levels of HICP across countries, we apply a similar methodology as Chen and Devereux (2003) for U.S. city CPIs. First of all, all indices are converted into a common currency (DM/euro) using annual averages of market exchange rates. Next, we convert the HICPs into absolute price levels by using the price level differences between countries that Eurostat publishes from 1995 onward.[5] We take these absolute price levels for one particular year and calculate back and forward in time the absolute price levels by using the national HICP time series. Formally, the HICP for product basket g in country j is scaled by the absolute price level P_{j1999}^{g} of product basket g in country j in 1999:

$$P_{jt}^{g} = (HICP_{jt}^{g} / HICP_{j1999}^{g})P_{j1999}^{g} \qquad g=1,...,G \qquad j=1,...,n \qquad t=1960,...,2003 \tag{4.8}$$

In Section 4.5, we show that this approximation of the underlying absolute values of HICP is reliable. Aggregate price levels from 1960 onward for 20 U.S. cities are constructed similarly.[6]

[3] Source: OECD Economic Outlook (Number 75, June 2004).

[4] Source: Eurostat Cronos. Missing data for Austria, Finland, and Sweden over the period 1980-1985 have been obtained from the national statistical agencies. Extra data required for connecting the CPI and HICP were provided by the national statistical offices of Austria, Germany, Ireland, Finland, and Sweden.

[5] Source: Eurostat Cronos.

[6] Source: Bureau of Labor Statistics and Cecchetti, Mark, and Sonora (2002) for city CPIs; Koo, Phillips, and Sigalla (2000) for comparable city price levels. See also Chen and Devereux (2003).

4.2.2 Supplemental data

Following the model specification, additional data are necessary on indirect tax rates, nontraded input costs, exchange rate volatility, openness, and the share of nontraded inputs. Nine different U.S. regions will be considered since for some of the determinants (notably openness) it is more suitable to compare European countries with nine U.S. regions than with, for example, all individual states. These regions are often used by statistical agencies.

National and regional indirect tax rates (τ_{jt}) are calculated via total indirect taxes divided by private consumption.[7] To approximate nontraded input costs (W_{jt}), we take the per capita gross domestic (or region) product (GDP) at factor costs converted to common units using purchasing power parity (PPP) measures.[8] Long-term European exchange rate volatility (vol_t) is measured by the standard deviation of all monthly changes in the exchange rate of a country against the German mark in 1 year, averaged over all countries in the group and over 8 years.[9] Of course, for the United States there is no exchange rate volatility. Openness ($open_t$) is measured for Europe by the level of actual trade, namely, the level of exports of goods from countries in the group to other EU countries (members in 2003), as a percentage of the group's GDP.[10] Unfortunately, long-term data on intra-U.S. trade are not available. On the basis of the Commodity Flow Survey, which offers the most comprehensive nationwide source of freight data, the value of goods traded between regions is estimated for the years 1977, 1993, 1997, and 2002.[11] This value is expressed as a percentage of the U.S. GDP. The share of nontraded inputs (α) is set at 0.6.

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7 Source: OECD Economic Outlook and additional data from the World Development Indicators database (Europe) / Asdrubali, Sørensen, and Yosha (1996), Bureau of Economic Analysis, and U.S. Census Bureau (Statistical Abstract of the United States and State and Local Government Finances) (United States).

8 Source: OECD Economic Outlook and additional data from the World Development Indicators database (Europe) / Bureau of Economic Analysis (United States). A correction is made for the German reunification.

9 Source: IMF IFS and Reinhart and Rogoff (2004).

10 Source: European Economy, The EU Economy: 2002 Review, No. 6 (European Commission 2002) and European Economy, The EU Economy: 2003 Review, No. 6 (European Commission 2003).

11 Source: Commodity Transportation Survey 1977 and Commodity Flow Survey 1993, 1997, and 2002. A correction is made for exports from the United States since these are included in the survey data.

Approximately 60% of the HICP basket consists of nontraded products (Maier (2004)). If these nontraded products require a traded input of say 10% and if traded products require a nontraded input of 15% (CTZ, data appendix, table A1), then it follows that $\alpha = 0.6 \cdot 0.9 + 0.4 \cdot 0.15 = 0.6$.

4.3 Trends in price level dispersion

4.*3.1 Trends at the aggregate level*

In Figure 4.1a price level dispersion is plotted for several combinations of European countries. These are an EMU group consisting of all 12 EMU members in 2003, an EU group consisting of all 15 EU members in 2003, and the DM zone. As a benchmark, U.S. city price level dispersion is included as well.[12]

All European country groups show a declining trend in price level dispersion over much of the last 45 years. Roughly speaking, for the EMU and the EU, three periods can be distinguished: 1960-1973 was a period of rapid decline in price level dispersion, 1974-1987 was a period of stagnation, and 1988-2003 was a period in which price level convergence regained momentum. Compared to 45 years ago, price level dispersion in the EMU has been halved. These findings make sense if we think about the history of European economic integration policy as briefly described in the introduction. The 1960s, early 1970s, and 1990s are characterized by cooperation, harmonization, and several European milestones, while in the second half of the 1970s and first half of the 1980s, European cooperation and integration policy stagnated.

Price level differences within the DM zone have always been substantially lower and convergence has been stronger in relative terms. From 1960 on, price levels steadily

[12] Since the 20 cities for which data are available are not evenly distributed over the nine regions, the U.S. line represents price level dispersion between these 20 cities. However, a rough approximation of the appropriate line for the nine regions is similar.

converged in the DM zone. In the second half of the 1980s, price level dispersion reached its lowest level, which is close to zero. At the beginning of the 1990s, price level dispersion in the DM zone rose somewhat, possibly as a result of the German reunification. In more recent years, price level dispersion declined again. The price level dispersion of the DM zone in the early 1960s is comparable to the EMU's present level.

Figure 4.1a also displays U.S. city price level dispersion. First of all, price level dispersion rates in the EMU and the EU are structurally higher than in the United States. However, the gap between the two has gone down substantially. This is mainly the result of price level convergence in Europe. In the United States, price level dispersion is relatively stable, although it increased a bit since the 1980s. In the DM zone, price level dispersion was higher in the beginning of our sample compared to the United States, but is nowadays below U.S. price level dispersion. The comparison with the United States suggests that European-specific factors have been at work. To investigate this further, we take the DM zone, the EMU, and the United States as our starting point for a more detailed analysis in Section 4.4.

4.3.2 Trends at the one-digit product level

Is the overall picture representative? Aggregate HICP may be subject to a summation bias. In this section, we take a closer look at this issue by applying our methodology to seven one-digit HICP subcategories. We first classify the subcategories as traded or nontraded (Maier (2004)).

Housing is classified as nontraded. *Alcoholic beverages and tobacco* is nontraded as well, as price levels are to a large extent determined by taxes. *Food* and *Clothing and footwear* are traded subcategories. *Furnishings, Transport and communications*, and *Recreation and culture* contain both traded and nontraded products. The subcategory *Furnishings* consists

Figure 4.1a HICP price level dispersion

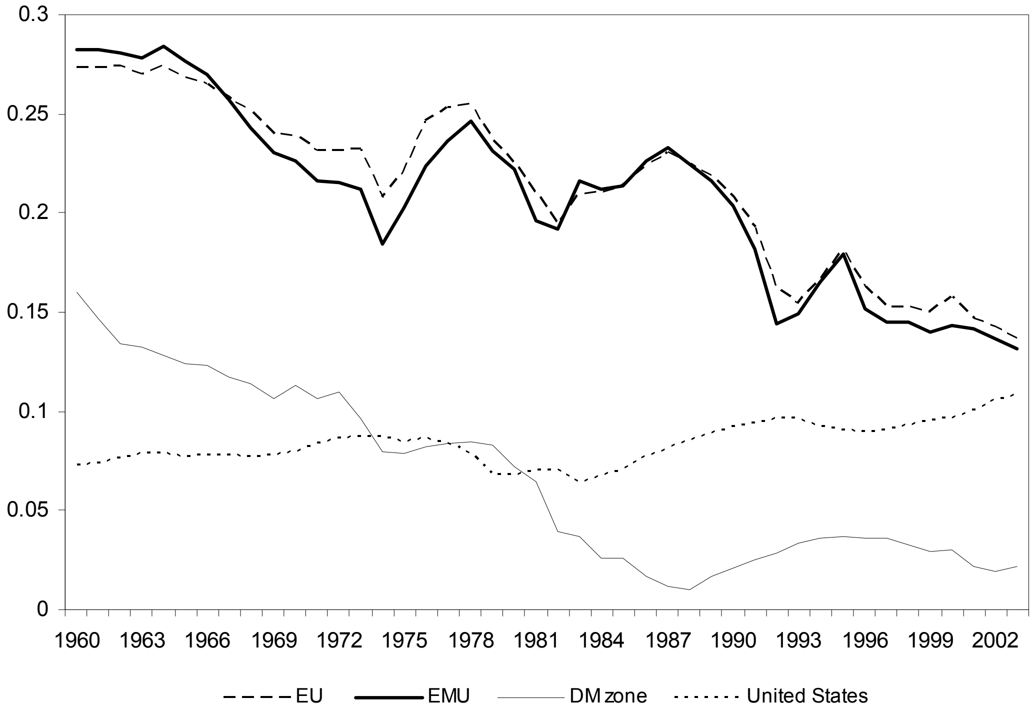
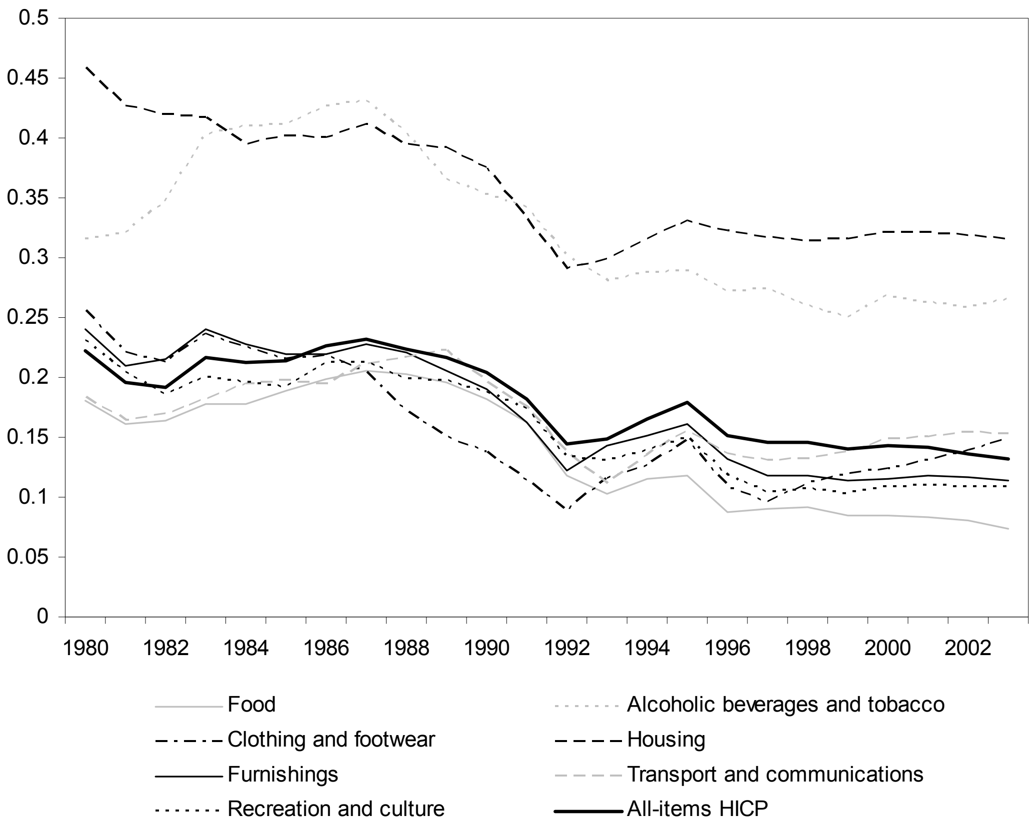


Figure 4.1b HICP subcategory price level dispersion EMU



almost completely of traded products. *Recreation and culture* has more or less an equal share of traded and nontraded products. *Transport and communications* contains relatively many nontraded products.

EMU trends of the one-digit subcategories are depicted in Figure 4.1b. Price level dispersion patterns for subcategories are in line with the pattern for aggregate HICP. For all subcategories, price level dispersion was more or less stable up to 1986-1987 but started to decline afterward. In the early 1990s, there is strong price level convergence for all subcategories.

Although all subcategories show a similar trend, there are differences. First, in general, traded subcategories have a lower price level dispersion than nontraded subcategories. For example, price level dispersion is three to four times smaller for the traded subcategory *Food* than for the nontraded subcategories *Alcoholic beverages and tobacco* and *Housing*. Second, over the whole sample period price levels of the subcategories *Food*, *Clothing and footwear*, *Furnishings*, and *Recreation and culture* converge most in relative terms. So, traded subcategories show a lower price level dispersion and more convergence than nontraded subcategories. HICP subcategories for other European country groups and at higher digit levels (for a smaller set of countries) show similar patterns.

The fact that traded and nontraded subcategories follow roughly a similar trend suggests that a possible bias due to summation is perhaps not such a problem.[13] Moreover, these similar trends might make sense if one considers that both types of subcategories have a traded and a nontraded input component, as argued in Section 4.1. If nontraded (traded) input costs converge, this has an impact on traded (nontraded) subcategories as well. It is also possible that factor price equalization is at work.

[13] Disaggregated price level data may help us to get an impression of the possible error that arises from ignoring the second term in Equation (4.4). We take a country's price level of housing (a subcategory with a relatively high share of nontraded inputs) as a proxy for W_{jt} and a country's price level of food (a subcategory with a relatively high share of traded inputs) as a proxy for Q_{jt}. The correlation between the logarithms of these two is on average 0.73 over the period 1980-2003. With α=0.6, the second term in Equation (4.4) is about one-tenth of the first term.

4.4 Determinants of price level dispersion

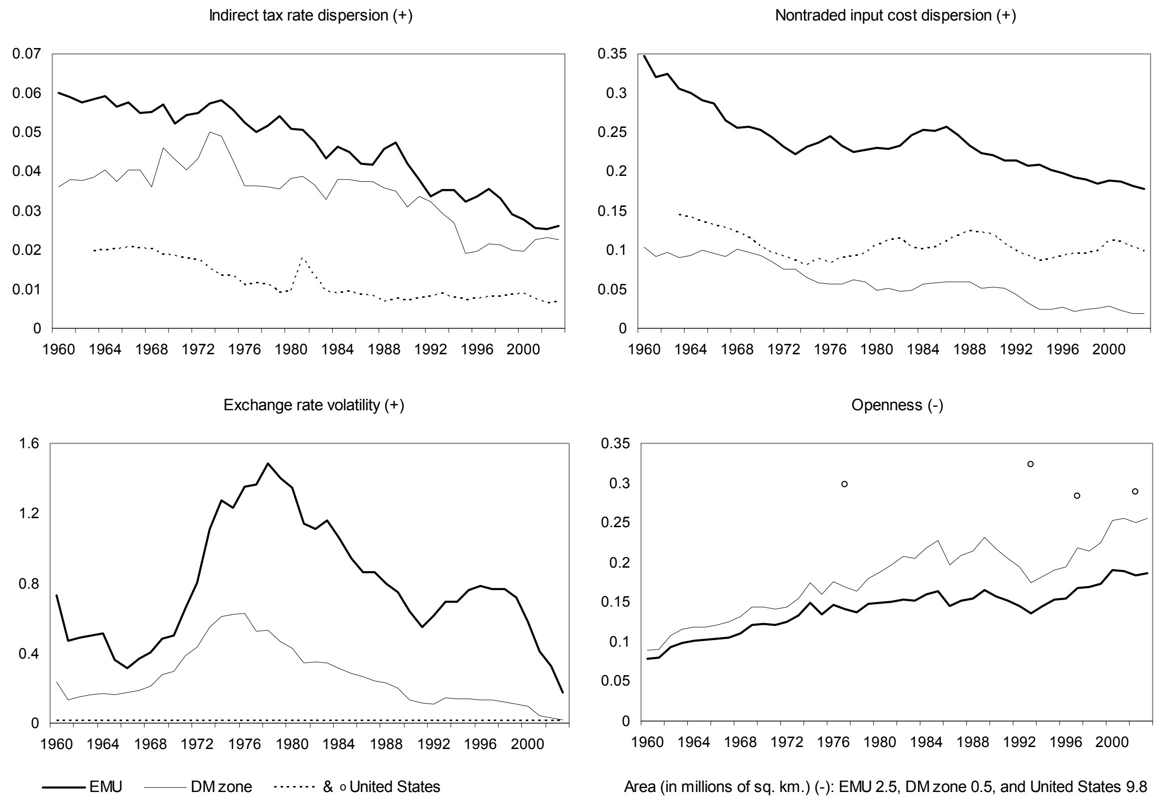
Which factors may explain price level dispersion in Europe over the last 45 years? How important has European integration policy been? To investigate these questions we start with a qualitative, visual inspection of the determinants of price level dispersion and compare these with those for the United States. Second, we use the adapted CTZ model to make a tentative quantitative assessment of the contribution each determinant has made to price level convergence in Europe.[14]

The model in Section 4.1 identifies differences in indirect tax rates (τ_{jt}), nontraded input cost dispersion ($\sigma(w_t)$), exchange rate volatility (vol_t), and openness ($open_t$) as determinants of price level dispersion, where the latter two represent traded input cost dispersion. Figure 4.2 shows the developments over time of these four determinants for the EMU, the DM zone, and the United States (the standard deviation of the indirect tax rates is plotted). The figure shows that in periods of declining price level differences between the EMU countries - the 1960s up to the early 1970s and the late 1980s and onward - various factors operated simultaneously in the right direction. During both periods, indirect tax rates were harmonized and nontraded input costs converged. These periods are also notable for exchange rate stability and an increase of openness. In between, price level convergence stagnated. Remarkably, nontraded input cost dispersion also remained stable and the growth of openness stagnated in this period. Another factor was the turbulence on the foreign exchange markets following the collapse of Bretton Woods in 1971.

In the DM zone, price level convergence proceeded at a steady pace, accelerated in the 1980s, and was later interrupted at the time of the German reunification. Figure 4.2 shows that in the first three decades, convergence of nontraded input costs, exchange rate stability, and increased openness made a combined contribution. The figure also sheds

[14] Luxembourg is excluded from the analysis since it would have a disproportionate influence on the overall results.

Figure 4.2 Determinants EMU, DM zone, and United States



Note: Here, + (-) indicates a positive (negative) link to price level dispersion.

light on why price level dispersion in the DM zone was always smaller than in the EMU: more similar indirect tax rates, a lower dispersion of nontraded input costs, more stable exchange rates, and a higher openness.

Interestingly, in the United States, where there was hardly any change in the price level dispersion compared to Europe, dispersion of indirect tax rates and nontraded input cost dispersion were also stable over time. Figure 4.2 shows that in the 1960s indirect tax rates were more diverse in Europe than they were in the United States, but differences in Europe steadily declined over time. Moreover, over the whole sample the dispersion of nontraded input costs is higher in the United States than in the DM zone, but lower than in the EMU. However, due to the strong decrease of nontraded input cost dispersion in the EMU, its levels are coming closer to those of the United States in the early 2000s. Our approximation of openness suggests that the U.S. regions have always been much more integrated than the EMU countries. For example, in 1977, the openness of the United States was twice as large as the openness of the EMU (30% vs. 14%). In recent years, differences in openness between Europe and the United States have become substantially smaller, but have not completely disappeared.

As a final remark it should be noted that the EMU and the DM zone are geographically much more compact than the United States. With almost 10 million square kilometers, the U.S. territory is 4 times larger than the EMU and almost 20 times larger than the DM zone.

Next, we use the adapted CTZ model from Section 4.1 to make a back-of-the-envelope calculation of the contributions of the various factors to overall price level dispersion in the EMU (see Equation (4.7)). Recall that the model is formulated in terms of price levels excluding indirect taxes and that the share of nontraded inputs (α) is known to be 0.6. As a robustness check we will also present results for $\alpha = 0.5$.[15] The elasticities belonging to exchange rate volatility and openness - for which *a priori* information is lacking - can be estimated freely. This gives the following equation:

$$\sigma(p_t^*) - \alpha\sigma(w_t) = (1-\alpha)[\beta_0 + \beta_1 vol_t + \beta_2 open_t] \tag{4.9}$$

Our sample is for 1960-2003. All variables under consideration have a unit root of order 1 (Table 4.1). To establish whether the combination of $\sigma(p_t^*) - \alpha\sigma(w_t)$, vol_t, and $open_t$ forms a cointegrating relation, we apply the Johansen maximum likelihood procedure. Cointegration rank tests (maximum eigenvalue and trace) show the presence of one cointegrating relation at the 6% level of significance, which indicates the existence of a long-run relationship. As a robustness check we apply the Stock-Watson dynamic OLS (DOLS) approach. This method is a robust *single equation* approach that corrects for

[15] A value of 0.5 follows if we assume that nontraded products require a traded input of 25% instead of 10%.

Table 4.1 ADF unit root test statistics EMU

	Level	First difference
$\sigma(p_t^*)$ - $0.5\sigma(w_t)$	-2.81 (0.20)	-5.75 (0.00)
$\sigma(p_t^*)$ - $0.6\sigma(w_t)$	-3.02 (0.14)	-5.85 (0.00)
vol_t	-2.32 (0.41)	-4.14 (0.00)
$open_t$	-2.62 (0.27)	-7.39 (0.00)

Note: Between brackets are p-values.

regressor endogeneity by the inclusion of leads and lags of first differences of the regressors. Table 4.2 reports the summary statistics for the long-run relations. Both methods point in the same direction and deliver similar elasticities. Moreover, the results are not very sensitive to the choice of α.

Now, we take the long-run relation from Johansen with $\alpha = 0.6$ to decompose the price level dispersion in the EMU throughout the years. To identify the contribution of indirect tax rate harmonization we take the difference between the price level dispersion including and excluding indirect taxes. Table 4.3 presents the outcomes for the 5-year intervals. The exercise shows that the model is capable of identifying the main developments of price level dispersion and confirms the findings from the qualitative analysis. Nontraded input cost dispersion and openness are the most important factors for explaining the extent of price level dispersion. Moreover, indirect tax rate harmonization, convergence of nontraded input costs, exchange rate stability, and increased openness have all been fueling European price level convergence to substantial and varying degrees over time. In the period 1963-1973, changes in indirect tax rates, nontraded input costs, and openness contributed to price level convergence. After 1973, the contribution of these factors stabilized, but after 1988 harmonization of indirect tax rates and nontraded input cost convergence decreased price level dispersion again. Openness contributed again to price level convergence from 1993 onward. Over a time span of 40 years (1963-2003), indirect

Table 4.2 Estimated long-run elasticities EMU

$\sigma(p_t^*) - \alpha\sigma(w_t)$	α=0.5 Johansen	α=0.5 DOLS	α=0.6 Johansen	α=0.6 DOLS
β_1	0.051	0.051	0.059	0.060
	(2.0)	(2.6)	(1.9)	(2.6)
β_2	-2.06	-1.59	-2.19	-1.63
	(6.4)	(5.9)	(5.5)	(5.0)
cointegration	one cointegrating relation*	residual stationary*	one cointegrating relation#	residual stationary*

Notes: Between brackets are t-statistics. In this table, * denotes 5% significance level, # denotes 6% significance level.

Table 4.3 How much each determinant contributed to price level convergence in the EMU

	Price level dispersion		Estimated contribution				
	(1) Measured	(2) Predicted	(3) C	(4) Ind. tax rate disp.	(5) Nt. input cost disp.	(6) Exch. rate volatility	(7) Openness
1963	0.281	0.298	0.156	0.033	0.183	0.012	-0.086
1968	0.243	0.253	0.156	0.032	0.153	0.010	-0.097
1973	0.209	0.220	0.156	0.022	0.133	0.026	-0.117
1978	0.241	0.230	0.156	0.025	0.134	0.035	-0.120
1983	0.224	0.214	0.156	0.016	0.148	0.027	-0.133
1988	0.233	0.198	0.156	0.020	0.140	0.019	-0.136
1993	0.151	0.194	0.156	0.016	0.124	0.016	-0.119
1998	0.148	0.153	0.156	0.013	0.114	0.018	-0.148
2003	0.134	0.112	0.156	0.009	0.107	0.004	-0.164
2003-1963	-0.146	-0.186	0	-0.024	-0.076	-0.008	-0.078

Note: Because of rounding, columns 3 to 7 might not add up to column 2.

tax rate harmonization is responsible for almost 15% of European price level convergence, convergence of nontraded input costs for about 40%, and the increase in openness for about another 40%. According to our calculation, rising exchange rate volatility explains much of the stagnation in the 1970s and early 1980s. Exchange rate stability made a substantial contribution to price level convergence in more recent years. In terms of the model, the dispersion of nontraded input costs and the dispersion of traded input costs are both important for explaining price level dispersion and its decline.

4.5 Comparisons and reliability

In this section, we discuss the results and reliability of our method by comparing our estimates of price level dispersion with (i) benchmarks from official statistical agencies, (ii) trends from large microdata sets, and (iii) detailed microdata.

4.5.1 Official statistical agencies

For our sample we have a few benchmarks from several OECD publications. Data are available for 1980, 1985, 1990, 1993, 1996, 1999, and 2002 for all EMU countries.[16] There is a large degree of similarity of price levels. Figure 4.3a shows dispersion rates based on our data and the OECD data for the EMU from 1980 onward. For each year, price level dispersion rates based on our constructed data have a small deviation from dispersion rates based on the OECD data. The results are also satisfying for the various subcategories.[17]

As mentioned before, from 1995 onward Eurostat publishes annually international price level differences for all product categories.[18] We use the data for 1999 to scale our HICPs. If we take one of the other years for scaling the HICPs, then our results do not change much. Moreover, our constructed data are consistent with Eurostat price levels for the aggregate HICP and subcategories over the period 1995-2002.

[16] Source: Several publications of the OECD series "Purchasing Power Parities and Real Expenditures". See Purchasing Power Parities and Real Expenditures: 1999 Benchmark Year (OECD 2002, p. 7) for more information.

[17] Chen and Devereux (2003) use a similar method to construct absolute price level data for U.S. cities for the period 1918-2000. They test reliability via two benchmarks (1935 and 1975) and conclude that their constructed price levels are close to these benchmarks.

[18] These data also serve as input for the OECD data.

Figure 4.3a Price level dispersion HICP versus OECD

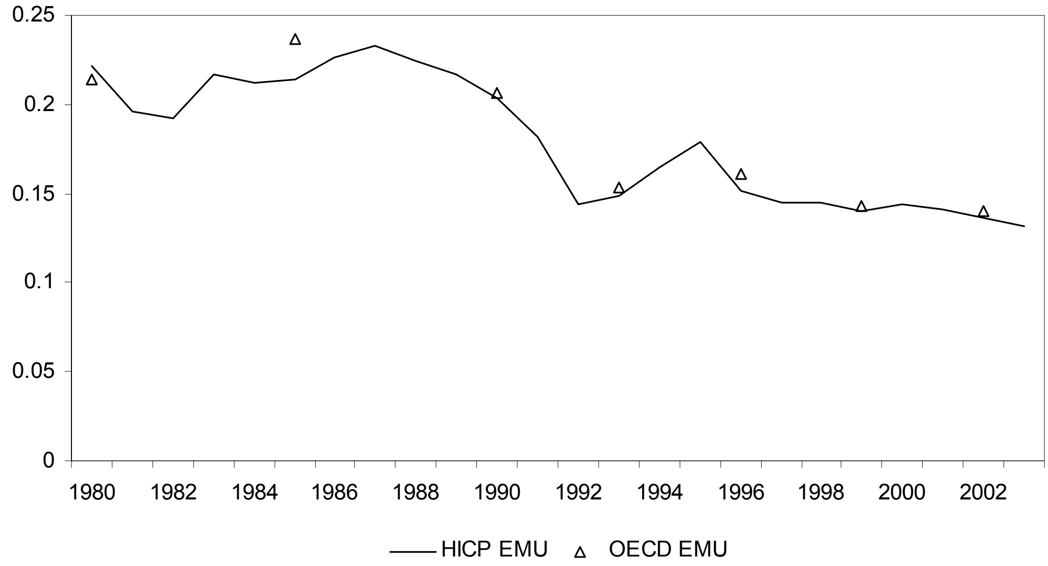
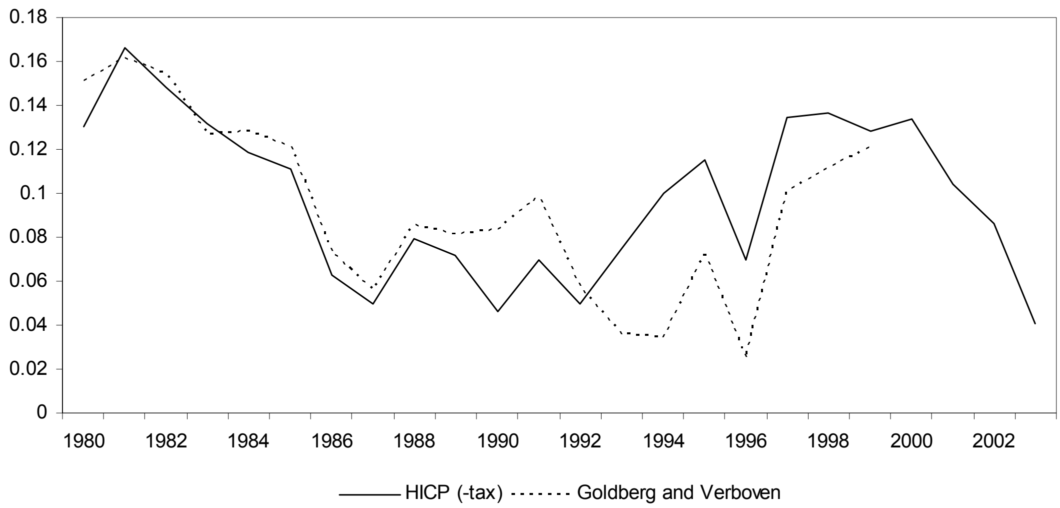


Figure 4.3b Price level dispersion HICP Purchase of vehicles versus Goldberg and Verboven



4.5.2 Microdata sets

Interestingly, the overall picture that emerges from our macroapproach also compares well to evidence from the large microdata sets mentioned in the introduction of the chapter. These data sets are much more detailed than our data but cover shorter time spans. CTZ use Eurostat microdata for 4 individual years (1975, 1980, 1985, and 1990) and is authoritative in terms of coverage of a common basket of products across Europe. For example, for 1990 the data set contains almost 1,900 different retail goods and services (54% of the goods are even branded) for 13 countries. Based on this data set, CTZ find no convergence between the 4 years considered, which is in line with our findings (see Figure 4.1a).[19] Rogers (2007) uses the EIU data set that covers a significant number of items (157) with higher frequency (annually, 1990-2004) for 38 European and U.S. cities. Figure 4.1a shows a downward trend with strong convergence in the early 1990s as does the EIU data set for the period 1990-2003.[20]

4.5.3 Detailed microdata: a comparison with Goldberg and Verboven

One of the best-known and well-founded studies on European price level convergence is the project on European car prices (see Goldberg and Verboven (2001), (2004), (2005), Lutz (2004)). Goldberg and Verboven collected an impressive data set on individual car prices throughout the years. The authors make corrections for different tax regimes and differences in standard equipment across borders and car models. Based on this information, the authors are in a position to provide solid evidence of European price level convergence.

As a comparison, we take the two-digit HICP subcategory *Purchase of vehicles*. This subcategory is broader since it covers, in addition to cars, bicycles and motorcycles. However, cars have the largest weight in this HICP subcategory. We compare our scaled HICP data with annual national car price levels of the five largest car markets in Europe for the period 1980-1999. Since these price levels are without tax, we deduct taxes from

[19] Note that the extent of the price level dispersion reported in our study is not one to one comparable to CTZ dispersion levels.

[20] CTZ and Rogers (2007) argue that their data sets are consistent with CPI data. Moreover, they argue that for their results it does not matter much if products are CPI weighted or equally weighted.

our HICP price levels. We use the same group of countries. In Figure 4.3b, the trend line based on our data is depicted against the trend line based on Goldberg and Verboven. After an increase in price level differences in the beginning of the 1980s, both data sets show price level convergence. Peaks and troughs are roughly found at the same moment. In the late 1990s, both approaches signal a sharp rise in price level dispersion. The resemblance is remarkable. All in all, there are strong indications that our methodology produces reliable estimates of price level dispersion at the aggregate level, as well as at disaggregated levels.

4.6 Conclusion

There are several studies on European price level convergence. Due to data limitations these studies cover just parts of the European integration process. Moreover, because these studies use relatively short sample periods with relatively little variation of price levels, it is difficult to identify the determinants of price level convergence.

We extend the period of investigation by scaling HICP data. This methodology provides price level data for almost the complete period of European integration (1960-2003) and puts us in the position to study the determinants of price level convergence. We find that over much of the last 40 to 50 years, there is strong evidence of price level convergence in Europe toward levels that have been common in the United States for a long time. European price level differences roughly halved. An analysis of the determinants of price level dispersion suggests that indirect tax rate harmonization, convergence of nontraded input costs, and convergence of traded input costs (in the form of exchange rate stability and increased openness) all contributed to different extents and in varying degrees over time to European price level convergence.

It is important to note that price level dispersion between the EMU countries already converged close to U.S. levels before the introduction of the euro. Although the back-of-the-envelope calculation shows that exchange rate stability contributed significantly to price level convergence over the decades, it has a smaller effect than the aforementioned real factors. A topic for further research is to what extent the introduction of the common currency contributes to long-term price level convergence.

Chapter 5

Summary and Directions for Further Research

This thesis focuses on three different aspects of price setting. Chapter 2, 3, and 4 each study one of these aspects.

Chapter 2 discusses price setting and suggested prices. It analyzes the role of suggested prices in the Dutch gasoline market. In this market, oil companies announce suggested prices with the suggestion that retailers follow these prices. There exist at least two competing explanations for these suggested prices: (i) to inform retailers how they could take changes in the gasoline spot market price into account when setting their retail prices, and (ii) to coordinate pricing decisions. To test these two explanations, I use daily prices of almost all gasoline stations and oil companies in the Netherlands over more than two years. I find that there is, compared to the spot market price, additional information in suggested prices that explains retail prices. This means that suggested prices have a coordinating effect. I discuss different interpretations of this result. It is possible that this result is caused by a coordinating effect on retail prices of gasoline stations or that it is caused by a coordinating effect on wholesale prices of oil companies. Since I do not have information on wholesale prices, I cannot say with certainty which of these two interpretations is correct. However, whichever of these interpretations is true, suggested prices certainly have a coordinating effect for the vertical chain of oil companies and retailers as a whole. Since each oil company announces its own suggested price, I distinguish a general across brand influence of suggested prices on retail prices and a brand-specific effect. I conclude that there is a coordinating effect of suggested prices across brands and within brands. A suggestion for policy makers is to further investigate whether suggested prices should be forbidden. To my knowledge, this is the first study that empirically tests the coordinating effect of suggested prices.

Chapter 3 studies price setting and asymmetric price responses. Asymmetric price responses occur when prices rise more rapidly after an increase in costs than they decline after a decrease in costs. This chapter focuses on the price setting of individual firms. I study whether gasoline stations and oil companies in the Netherlands respond asymmetrically to changes in the spot market price for gasoline. Moreover, I study the characteristics of gasoline stations that adjust prices asymmetrically. The same data set as in Chapter 2 forms the basis for the analysis. The main conclusion is that many gasoline stations do not adjust prices asymmetrically, but a substantial part of the stations do (38%). For asymmetrically pricing stations, the asymmetry is substantial directly after a change in the spot market price but disappears after one or two days. I do not find clear differences in the characteristics of stations that do and do not adjust prices asymmetrically. Asymmetric pricing seems to be a phenomenon that is randomly distributed over the population of gasoline stations. I also find that none of the five largest oil companies adjust their suggested prices asymmetrically. Studies to asymmetric pricing add to a better understanding of pass-through and sticky prices, which is important for macroeconomic policy. Moreover, the causes of asymmetry determine whether policy makers should interfere if they observe asymmetric price adjustments in a market. This chapter is the first study that looks at differences in the asymmetric pricing behavior of individual firms. Previous studies mainly focus on asymmetric pricing at the market level.

Chapter 4 studies price setting and European integration policy. During the last five decades, European countries made an enormous effort to integrate their national markets. In this chapter I detect trends in price level dispersion from the beginning of the European integration process and I identify the main determinants behind these trends. In other words: how successful has European integration policy been? I create long-term price level data that are comparable across countries by combining harmonized indices of consumer prices with occasional observations of absolute price levels. I find that European price levels converge over much of the last 40 to 50 years. During this period price level dispersion in the EMU roughly halves. Before and during the early 1970s and during the 1990s there is convergence. The convergence stagnates in the second half of the 1970s and first half of the 1980s. In the United States, my benchmark, price level dispersion is more or less stable. This finding suggests that convergence is a typical European process. The determinants of price level dispersion confirm this impression. A back-of-the-envelope calculation suggests that indirect tax rate harmonization, convergence of nontraded input costs, and convergence of traded input costs (in the form of exchange rate stability and increased openness) are all important in explaining European price level convergence. Therefore, European integration policy has been important for the integration of the national markets. The study in this chapter is the first study that gives insight in the long-term development of European price level dispersion and its determinants.

5.1 Directions for further research

There is still a lot of empirical research possible to the coordinating effect of suggested prices (the topic of Chapter 2). All over the world suggested prices exist for many products, but there are only a few studies that focus on these prices. A first direction for further research is to study a market for which data are available on wholesale prices and the moments that retailers buy new stock, next to data on suggested prices, retail prices, and input prices. In Chapter 2 I can only conclude that there is a coordinating effect for the distribution chain as a whole. Although I perform indirect tests that give an indication, I cannot say with certainty whether the coordinating effect takes place at the level of oil companies or gasoline stations. Possibly, further research can make this distinction by studying markets for which the aforementioned additional data are available.

Another possibility for further research is to compare markets with and without a suggested price. In Chapter 2 I can test the coordinating effect hypothesis because in gasoline markets there is a clear best alternative in case that there would not be a suggested price. If there is not a suggested price, it is possible to coordinate on the spot market price. The coordinating effect hypothesis is difficult to test in markets that do not have a clear alternative focal point (like the cost of a major input or an equal wholesale price for all firms) since it is hard to convincingly argue what firms would do if there would not be a suggested price. One approach to still test the coordinating effect hypothesis in these kind of markets is to collect data on a comparable market without a suggested price. For example, it is possible to look at the same market in another country. Under the assumption that the markets are equal in all other aspects, I expect that prices are more similar in the market with a suggested price. Another option is to look at a market in which a suggested price is introduced or abolished. For example, for psychologists in the Netherlands there used to be a suggested price and it would be interesting to compare consumer prices before and after the existence of this suggested price. Note that data on suggested prices are not necessary for these studies, although it would certainly be illustrative.

The direction for further research on asymmetric price responses (Chapter 3) is obvious, but challenging. To make further progress on this topic, the literature needs a comprehensive theory on why individual firms adjust prices asymmetrically. This theory should be tested on price data of individual decision makers. At the moment, there are many studies that provide empirical evidence for the existence of asymmetric price adjustments. So far there is, however, very limited empirical evidence on the causes of asymmetric pricing. Researchers know it exists, but do not know why. Chapter 3 shows that in the market that I study the reason for asymmetric pricing is at the firm level. After all, only some stations in the market adjust their prices asymmetrically. There are quite a few theoretical studies that offer an explanation for asymmetric price adjustments at the firm level (see the references in Chapter 3). These studies mainly focus on tacit collusion or a low search intensity. However, to empirically disentangle these two explanations without an overarching theoretical framework is inherently difficult. For many measurable characteristics of a firm the two theories predict similar effects on asymmetry and for some other measurable characteristics the two theories predict opposite effects such that if both theories are correct and are at work at the same time, it is possible that there is no visible effect in the data (see also Verlinda (2008)). Also the theoretical relation between search intensity and measurable characteristics is not always straightforward (see, e.g., Janssen and Moraga-González (2004) and Chandra and Tappata (2008)). A comprehensive theory, at the firm level, on why asymmetric price adjustments exist would provide empirical researchers the tool to further investigate this issue.

The following three directions for future research are on European price level convergence (Chapter 4). First, the impact of the introduction of the euro needs further study. Allington, Kattuman, and Waldmann (2005) show that the euro has a positive impact on price level convergence in the short run. Chapter 4 shows that long-run exchange rate stability is important for explaining price level convergence. The sample in this chapter ends four years after the introduction of the euro (2003). It is interesting to find out whether the euro gives, next to the expected effect due to exchange rate stability, an additional boost to price level convergence in the long run. Is there something special about a monetary union?

A second direction is to study whether there is a "lower limit" of European price level dispersion. It is possible that there will always exist some price differences between national markets, no matter how much integration policy will take place in the future. After all, also within the current national markets there exist price differences. In Chapter 4, I show that at the end of the sample the EMU price level dispersion is slightly higher than the U.S. price level dispersion (see also Rogers (2007)). Since the U.S. price level dispersion has been more or less stable over time, this could be the lower limit of price level dispersion in a fully integrated market. However, more European integration and harmonization policy still seems possible. Moreover, the EMU is geographically much more compact than the United States. It is interesting to study whether there is a natural minimum level of dispersion in the EMU as well.

Finally, new studies that use microdata can still provide additional insights and support (or refute) studies that use macrodata (in particular studies that use microdata sets that cover broad sets of products are useful).

Nederlandstalige samenvatting
(Summary in Dutch)

Dit proefschrift draagt bij aan een beter begrip van de prijsbepaling van bedrijven. Ik bestudeer zowel micro- als macroprijsdata en zoek naar patronen in deze data. Via deze patronen vind ik determinanten van deze prijzen en achterhaal ik de redenen waarom bedrijven voor deze prijzen hebben gekozen. Ik richt mij in dit proefschrift op drie verschillende aspecten van prijsbepaling. Als eerste bestudeer ik of adviesprijzen een coördinerend effect hebben op de prijsbepaling van individuele bedrijven. Daarna onderzoek ik of bedrijven hun prijzen asymmetrisch aanpassen na een verandering in de kosten. Als laatste kijk ik naar het effect van Europees integratiebeleid op consumentenprijzen in verschillende landen.

Het eerste onderwerp is prijsbepaling en adviesprijzen (Hoofdstuk 2 van het proefschrift). Ik bestudeer de rol van adviesprijzen in de Nederlandse benzinemarkt. In Nederland geven oliemaatschappijen adviesprijzen aan benzinestations als richtsnoer voor de prijzen die de stations zelf kiezen. Er zijn ten minste twee mogelijke redenen waarom oliemaatschappijen adviesprijzen geven. De eerste reden is om benzinestations te adviseren hoe de verandering van de internationale marktnotering van benzine in de verkoopprijs te verrekenen. De tweede reden is om prijsbeslissingen te coördineren. Als adviesprijzen slechts de verandering van de internationale marktnotering bevatten, dan geven adviesprijzen geen extra mogelijkheden voor coördinatie vergeleken met de situatie zonder adviesprijzen. De internationale marktnotering is immers al publieke informatie. De relevante onderzoeksvraag is dan ook of de situatie met adviesprijzen meer mogelijkheden geeft voor coördinatie dan de situatie zonder adviesprijzen. Met andere woorden: komt eventuele extra informatie in de adviesprijzen ten opzichte van de internationale marktnotering terug in de pompprijzen? Om deze vraag te beantwoorden, gebruik ik dagelijkse prijzen van bijna alle benzinestations in Nederland en de dagelijkse adviesprijzen van de vijf grootste oliemaatschappijen voor een periode van meer dan twee jaar. Het blijkt dat, naast de internationale marktnotering, de extra informatie in de adviesprijzen belangrijk is voor het verklaren van de pompprijzen. Dit bekent dat adviesprijzen een coördinerend effect hebben. Ik bespreek meerdere interpretaties van dit resultaat. Het is zowel mogelijk dat dit resultaat wordt veroorzaakt door het coördinerende effect op de pompprijzen van stations als door het coördinerende effect op de handelsprijzen van oliemaatschappijen. Aangezien ik geen informatie heb over handelsprijzen, kan ik niet met zekerheid zeggen welke interpretatie de juiste is. Echter, adviesprijzen hebben hoe dan ook een coördinerend effect voor de hele keten van stations en oliemaatschappijen. Omdat alle oliemaatschappijen hun eigen adviesprijs hebben, maak ik een onderscheid tussen een algemeen coördinerend effect van adviesprijzen en een merkspecifiek coördinerend effect. Ik concludeer dat er zowel een coördinerend effect van adviesprijzen bestaat tussen merken als binnen merken. Een suggestie voor beleidsmakers is om het bestaan van adviesprijzen in de benzinemarkt nog eens goed te bestuderen met het oog op het mogelijk verbieden van deze prijzen. Voor zover ik weet, is dit de eerste studie die het coördinerend effect van adviesprijzen empirisch test.

Het tweede onderwerp is prijsbepaling en asymmetrische prijsaanpassingen (Hoofdstuk 3). Asymmetrische prijsaanpassingen vinden plaats als prijzen sneller stijgen na een verhoging van de kosten dan dat prijzen dalen na een verlaging van de kosten. In deze studie leg ik de nadruk op de prijsbepaling van individuele bedrijven. Ik onderzoek of benzinestations en oliemaatschappijen in Nederland hun prijs asymmetrisch aanpassen na veranderingen in de internationale marktnotering van benzine. Daarnaast bestudeer ik karakteristieken van stations die hun prijs asymmetrisch aanpassen. Ik gebruik dezelfde data als in de studie naar adviesprijzen. De belangrijkste conclusie is dat veel stations hun prijs niet asymmetrisch aanpassen, maar dat een substantieel gedeelte van de stations dit wel doet

(38%). Voor de meeste stations die hun prijs asymmetrisch aanpassen is de mate van asymmetrie direct na een verandering van de internationale marktnotering substantieel, maar deze asymmetrie verdwijnt voor het merendeel van de stations na één of twee dagen. Ik vind geen duidelijke verschillen tussen de karakteristieken van stations die hun prijs asymmetrisch aanpassen en de karakteristieken van andere stations. Asymmetrisch prijsgedrag lijkt een verschijnsel dat willekeurig is verdeeld over Nederlandse benzinestations. Ik vind ook dat geen van de vijf grote oliemaatschappijen haar adviesprijs asymmetrisch aanpast. Studies naar asymmetrische prijsaanpassingen dragen bij aan een beter begrip van starre prijzen en de manier waarop bedrijven kosten doorrekenen. Dit is belangrijk voor macro-economisch beleid. Bovendien is de oorzaak van asymmetrische prijsaanpassingen belangrijk voor beleidsmakers om te bepalen of zij moeten ingrijpen als zij dit prijsgedrag observeren. Dit is de eerste studie naar asymmetrisch prijsgedrag waarin specifiek wordt gekeken naar de verschillen tussen individuele bedrijven. Eerdere studies kijken voornamelijk naar asymmetrie in de markt als geheel.

Het laatste onderwerp is prijsbepaling en Europees integratiebeleid (Hoofdstuk 4). In de laatste vijf decennia hebben Europese landen intensief samengewerkt om hun nationale markten te integreren. Sterker geïntegreerde markten hebben kleinere prijsverschillen. Ik bestudeer trends in de spreiding van Europese prijsniveaus vanaf het begin van het integratiebeleid. Daarnaast identificeer ik de belangrijkste determinanten van deze trends. Met andere woorden: hoe succesvol is Europees integratiebeleid? Ik creëer internationaal vergelijkbare data over prijsniveaus voor een lange periode door het combineren van geharmoniseerde indices van consumentenprijzen ("*HICPs*") met incidentele observaties van absolute prijsniveaus. Europese prijsniveaus zijn geconvergeerd tijdens het grootste gedeelte van de periode die ik bestudeer (1960-2003). Gedurende deze periode is de spreiding van de prijsniveaus ruwweg gehalveerd. Voor en tijdens de vroege jaren '70 en gedurende de jaren '90 is er convergentie. De convergentie stagneert gedurende de tweede helft van de jaren '70 en de eerste helft van de jaren '80. In de Verenigde Staten is de spreiding van de prijsniveaus min of meer constant. Dit suggereert dat convergentie een typisch Europees proces is. Dit beeld wordt bevestigd door de determinanten van de spreiding van de prijsniveaus. Een vluchtige berekening suggereert dat harmonisering van indirecte belastingniveaus, convergentie van niet verhandelbare inputkosten en convergentie van verhandelbare inputkosten (in de vorm van wisselkoersstabiliteit en openheid van Europese landen) belangrijk zijn voor het verklaren van de Europese convergentie. Europees beleid is dus belangrijk geweest voor de integratie van de nationale markten. Dit is de eerste studie die kijkt naar de spreiding van Europese prijsniveaus op de lange termijn en de determinanten hiervan.

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